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CONTENTS

COVER: The three-stage Thor-Delta rocket that on March 25th sent the artificial satellite Explorer X into an orbit extending to half the moon's distance. In this view at the Cape Canaveral launching site, the 78-pound payload is already in place, and the massive gantry is about to be moved away prior to firing. National Aeronautics and Space Administration photograph. (See page 257.)

RADAR CONTACT WITH VENUS	251
EARLY SOLAR EVOLUTION	
— Robert R. Brownlee and Arthur N. Cox	252
THE TRIPLE SYSTEM OF ETA GEMINORUM	
— Armin J. Deutsch	261
FURTHER FEBRUARY ECLIPSE OBSERVATIONS	
— Donald H. Menzel	263
INTERSTELLAR GAS CLOUDS	
— Otto Struve	269
AMATEUR ASTRONOMERS	276
BOOKS AND THE SKY	287
Tools of the Astronomer	
Outer Space Photography for the Amateur	
Michelson and the Speed of Light	
CELESTIAL CALENDAR	302
Delta Librae	
GETTING ACQUAINTED WITH ASTRONOMY	272
The Planets — Jupiter	
GLEANINGS FOR ATM's	293
An Oblique Reflector as a First Telescope	
LETTERS	262
NEWS NOTES	275
OBSERVER'S PAGE	278
March 2nd Partial Lunar Eclipse	
Observing the Moon — Kies	
Deep-Sky Wonders	
OBSERVING THE SATELLITES	257
QUESTIONS	274
STARS FOR MAY	305

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Radar Contact with Venus

STRONG, clear radio signals reflected back to the earth from Venus were observed on March 10th by the Goldstone tracking station of Caltech's Jet Propulsion Laboratory.

For the experiment, two 85-foot paraboloidal antennas were used, located seven miles apart in the Mojave Desert north of Barstow, California. The transmitting antenna sent a 2,388-megacycle-per-second signal toward Venus in a conical beam only 0.4 degree wide. The signal consisted of a series of very narrow pulses, with a sinusoidal change in frequency in order to make the returning echoes identifiable.

After the 6½ minutes required for the 74-million-mile round trip to Venus, the greatly weakened radar echoes were picked up by the other 85-foot antenna. The receiver used both a maser and a parametric amplifier, the heart of the former being a ruby cooled to the temperature of liquid helium to reduce receiver-generated noise power.

Successful repetition of radar contact with Venus was achieved on March 14th and 15th. This was the start of a program planned to continue until several weeks after Venus passed inferior conjunction with the sun on April 10th. The following day the distance of Venus from the earth reached a minimum of 26 million miles. Since the strength of the radar return diminishes with the fourth power of the planet's distance, observations are possible by existing techniques only when Venus is in the nearest parts of its orbit. Inferior conjunctions of this planet occur about 19 months apart; the next one will take place on November 12, 1962, the distance being 25 million miles.

The first reported radar contact with Venus was obtained in February, 1958, with the Lincoln Laboratory's antenna at Millstone Hill, in Massachusetts (SKY AND TELESCOPE, May, 1959, page 384). In that experiment, however, a year of analysis of tape-recorded observations was needed to distinguish the weak returned signals from background noise. The Goldstone experiment was the first in which the echoes could be immediately recognized without such elaborate processing.

One purpose of the two-month series of Goldstone observations, under the leadership of R. Stevens and W. K. Victor, is to redetermine the astronomical unit — the mean distance from Earth to Sun. It is also hoped to investigate the axial rotation of Venus. And a determination of the reflectivity of the planet's surface at the radar wave length of 12.6 centimeters may give useful clues to its physical nature.



Fig. 1. The computer room at Los Alamos Scientific Laboratory contains IBM 704's used by Robert R. Brownlee and Arthur N. Cox to compute their solar models. Tape storage units are at the left. The main computer console is at the back of the room, slightly right of center; the card punch and reader are in front and left of the console. All pictures and diagrams not otherwise credited are courtesy Los Alamos Scientific Laboratory.

Early Solar Evolution

ROBERT R. BROWNLEE and ARTHUR N. COX, *Los Alamos Scientific Laboratory*

AS LONG AGO as 1854, H. von Helmholtz proposed that the sun and other stars were radiating energy derived from their gravitational contraction. With this theory, Lord Kelvin in 1861 showed that the sun could not be much older than a few hundred million years. The Kelvin calculations, which assume that the sun's luminosity has been constant during its collapse, have given a contraction age of about 20 million years. This is the length of time that a body of solar mass would take to shrink from an infinitely large size to the sun's present dimensions.

In the 1920's, because the ages of terrestrial rocks were being determined as billions of years, this idea that the complete solar evolution was a contraction process had to be abandoned. Recent determinations of the age of the sun and solar system give a figure close to five billion years — more than 200 times the Helmholtz-Kelvin age. The most modern result for the time of the initial solar contraction, which is still believed to have occurred, is between 100 and 250 million years depending upon the original composition. This is about 10 times the approximate age calculated with the constant



Fig. 2. The extraordinarily versatile German scientist, H. L. F. von Helmholtz (1828-94). This portrait of the Heidelberg professor is from his "Theoretische Physik."

luminosity assumption, but still only a small fraction of the sun's total age.

The long solar past was made up of two stages. First, there was an initial contraction from a cloud of interstellar gas, when very likely the solar system was formed. Then came a stage of slow evolution, with hydrogen in the solar center being converted to helium by thermonuclear processes. During the first stage, the solar radius decreased steadily while the luminosity generally increased. Previous workers have found over the past 10 years that in the current second stage the sun is increasing its radius and luminosity simultaneously, but at a very slow rate. At the division between the two stages, the solar mass had a definite luminosity and radius, from which can be calculated its bolometric magnitude and effective surface temperature for that time. These numbers define what we call the *primordial sun*, which existed about five billion years ago.

Stellar models with masses both more and less than the solar mass undergo the same early history, and arrive at the slow thermonuclear energy-production stages in times dependent on their masses. Plotting the absolute bolometric magnitudes

of models versus their surface temperatures gives the theoretical Hertzsprung-Russell diagram. The positions of stellar models having identical compositions but different masses, at the time their contraction has just ceased, form a line on this H-R diagram called the *zero-age main sequence*.

The location of this sequence can be found with reasonable accuracy from observations of clusters such as the Hyades for stars with masses greater and less than the sun's. Both before and after their arrival on the zero-age main sequence, massive, more luminous stars evolve faster than do less massive ones. In the Pleiades cluster, the most massive stars have evolved away from the main sequence, but in certain other clusters we can observe faint, low-mass stars that have not yet fully contracted onto it. Observations of clusters that define the zero-age main sequence are compared with the theoretical sequence to find the composition of the stars in the solar neighborhood.

Details of this collapse stage in the early life of every star have interested astrophysicists for a long time. In 1955, extensive computations for a star of the sun's mass were made by L. G. Heney, R. LeVeier, and R. D. Levee. At the Los Alamos Scientific Laboratory, we have recently calculated for stellar material the opacity to the flow of radiation, and the equation of state, which relates pressure and energy to temperature and density. These data have made possible improved calculations of early solar evolution.

In this work, use has also been made of the most recent physical data on the production of energy by thermonuclear processes. The most important of these is the consumption of deuterium (H^2 = hydrogen of atomic mass 2) by fusion with hydrogen (H^1), forming helium of mass 3 (He^3), which through further fusion eventually becomes normal helium (He^4). When the model star arrives on the main sequence, the proton-proton chain is the main energy-producing process. Unfortunately, however, there is still enough uncertainty in these thermonuclear reaction rates to affect our calculations and conclusions.

The composition by mass of our models is almost the same as adopted by previous workers — hydrogen 74.4 per cent, helium 23.6, carbon 0.07, nitrogen 0.29, oxygen 0.57, neon 0.71, aluminum 0.15, silicon 0.13, and iron 0.09. We have done two problems — one with no deuterium, the other with just over 0.02 per cent deuterium by mass. The second case is based on the known abundance of H^2 on the earth and in meteorites. The energy produced in the H^2 and later He^3 transmutations has an important influence on the course of the collapse. During the evolution, because of the thermonuclear processes, the solar mass composition does not remain the same at all points in its interior.

In addition to physical properties, cer-

tain well-known physical laws must be used to calculate the structure and evolution of the solar mass. These laws or equations are of two types, the first concerning transport of energy by radiation, convection, and conduction. These are exactly the same processes we know in our everyday experience. (In the solar evolution discussed here, however, conduction is of negligible importance.) The second type of law concerns the motion of material, and determines throughout the interior how the force of gravity is balanced either partially or completely by the local pressure gradient. These equations of motion, together with one for the conservation of energy, are commonly referred to as the Navier-Stokes equations of hydrodynamics. We assume that the mass is not rotating, and thereby avoid difficulties of distortions from a sphere. The physical property equations, energy-flow equations, and hydrodynamic equations are all we need to study the early contraction of a solar model of assumed total mass and composition.

In applying these equations, several new methods have been developed. We

start by dividing one spherical solar mass into as many concentric shells as practicable — 30 in our calculations. The amount of mass in each does not change during the history of the contraction, but a shell thickness may and does vary. The masses in the individual layers are all different, having been chosen so that the initial thicknesses of the shells are approximately the same. Note that the loss of mass by conversion into energy, according to the famous Einstein equation ($E = mc^2$) has been neglected, and the mass of the model remains strictly constant.

To give a starting configuration, we have scaled up in size a model of the zero-age or primordial sun recently calculated by R. L. Sears at Indiana University. The scaling is called a *homology transformation*. In the simplest case, a star model of uniform composition is transformed into another homogeneous model whose shells are a factor f larger in radius, by dividing all temperatures at the shell mid-points by f and dividing all densities by f^3 . Other properties, such as the pressure and luminosity throughout the star, are determined uniquely by the assumed composition, mass distribution, temperature, and density. If in the original star model the gravity is exactly balanced by the pressure gradient (hydrostatic balance), as is true in the sun and other nonpulsating stars, then the homology transformation yields another star model also in exact balance — provided that the laws governing the properties of the material have not changed with the temperature and density.

For each of the 30 expanded shells of known mass, we now have a list giving temperature, density, and composition, all of which change with time. Our homology transformation to a radius about 25 times the zero-age main-sequence radius does not give a perfectly balanced model, because the material properties change too much with temperature and density. But after a very short evolution time we find the model to be in as good a balance as it ever achieves in its contraction stage.

We take an arbitrary interval for the first time step. The rates of energy flow across the shell boundaries depend on the

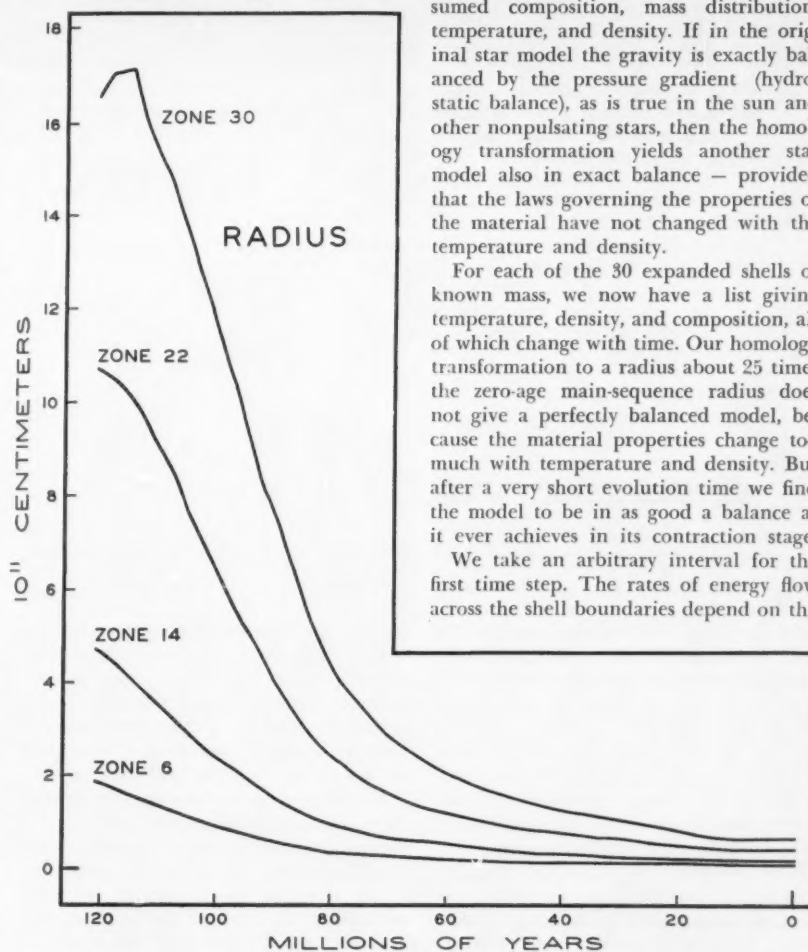


Fig. 3. Early evolutionary changes in the outer radii of several shells of the model without original deuterium. Contraction here is rapid, compared to that in the model that does initially contain deuterium. The time scale shows millions of years before the main-sequence phase is reached.

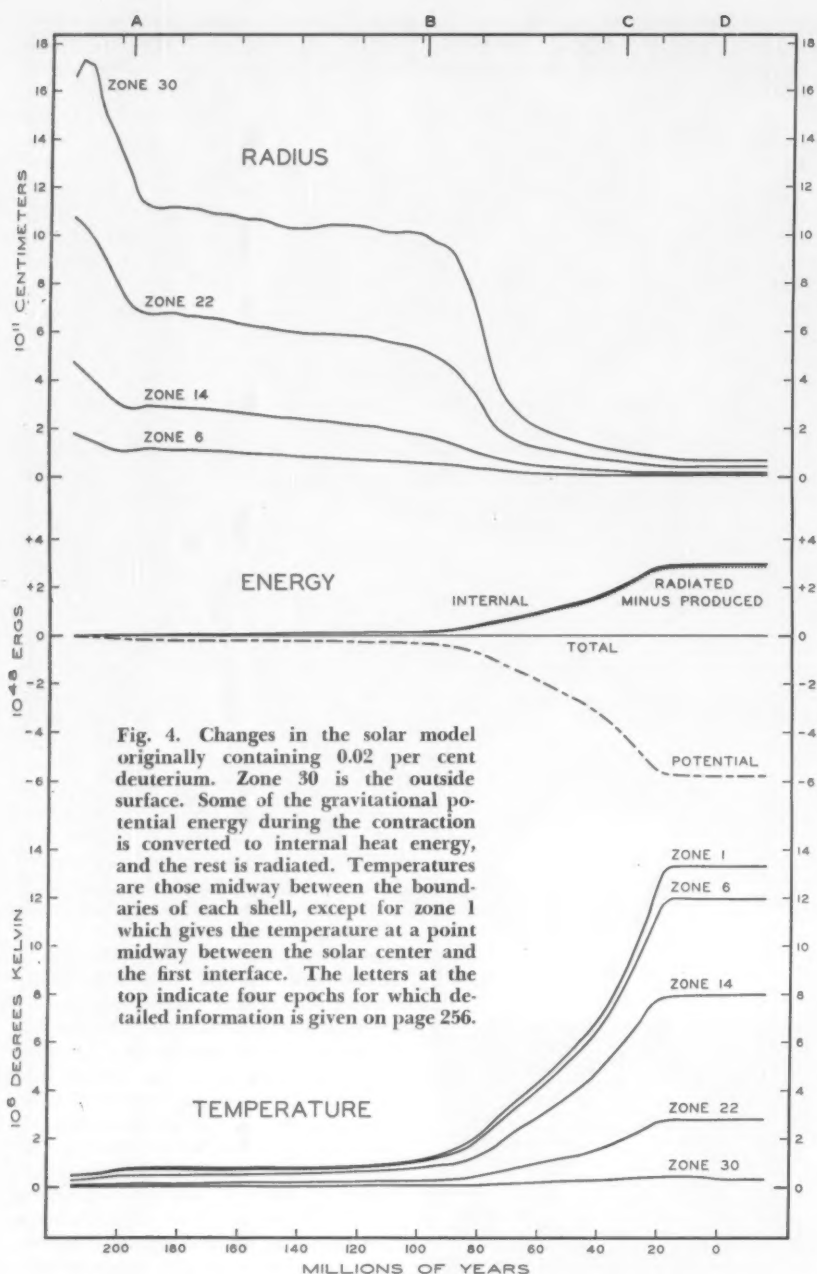


Fig. 4. Changes in the solar model originally containing 0.02 per cent deuterium. Zone 30 is the outside surface. Some of the gravitational potential energy during the contraction is converted to internal heat energy, and the rest is radiated. Temperatures are those midway between the boundaries of each shell, except for zone 1 which gives the temperature at a point midway between the solar center and the first interface. The letters at the top indicate four epochs for which detailed information is given on page 256.

local chemical composition, temperature, density, and temperature gradient. These rates are allowed to operate over the time step, so we can calculate the amount of energy that has been carried from each shell to its neighbor. The composition and energy-production laws enable us to calculate the energy produced by the thermonuclear processes and the change in composition during the time step. Also, the hydrodynamic equations use the pressure gradient and gravity to predict the motions of the shell boundaries as they seek a balance. Then, the new positions of the layer interfaces are used to calculate the new densities in the shells.

The net energy flow into a shell is combined with the mechanical work done

by it in expansion or contraction, and with the material properties of the mass in the shell, to give a net change in temperature at its mid-point. Our list of temperatures, densities, and compositions can now be modified for the new time, and we are ready for the second time step.

If changes in temperature or density have been rather large, the next step is chosen to have no more than half the duration of the preceding one. However, if the structure of the model is hardly changed by a time step, the next is taken twice as long. In this way, the evolution rate of the model determines the size of the time steps.

To follow all the details of solar evolution, we have programmed the principles

above into a code for use by the high-speed IBM 704 computers at the Los Alamos Scientific Laboratory (Fig. 1). About a thousand time steps are needed for the calculations described here, and therefore the average step is about 200,000 years.

The application of the hydrodynamic equation that predicts the motion of interfaces is not straightforward. Actually, the assumption is made that the model is in perfect hydrostatic balance at all times, and after energy has leaked out in one time step the interfaces are placed in balance again. Our calculations show that the balance is almost perfect even during the rapid collapse stages. The assumption of perfect balance at all times enables one to calculate the evolution with larger time steps, hence with more efficiency.

Special treatment of the convective energy transport is also necessary for efficient calculations. We constantly check to see that our defiance of the correct convection law does not cause noticeable error in the model structure. The most uncertain quantity is the outer radius, which may be in error by a few per cent at most.

Some results of the calculations for the model containing no original deuterium are given in Fig. 3. This shows how the radii of the interfaces between shells change with time. For clarity, only four of the 30 boundaries have been graphed. These are interfaces 6, 14, 22, and 30, where the last is the outside surface of the model. At first there is a very rapid adjustment in radius. Without any deuterium, the solar mass collapses to the zero-age main sequence in about 120 million years, to become a primordial sun with only 90 per cent of the present solar radius.

Fig. 4 shows how the radii, energies, and temperatures change with time when deuterium is added to the original composition. The H^2 burning holds the radius at about 16 times the main-sequence value until almost all this substance has been transmuted to He^3 . (The small variations in outer radius during this phase are due to computational difficulties.) Almost all the H^2 burns at a temperature of $800,000^\circ$ Kelvin and a density of 0.03 gram per cubic centimeter. The calculated changes in temperature are plotted in the bottom section of the diagram. The He^3 is not transmuted to normal He^4 until very late, when large temperature and density changes occur.

The middle part of Fig. 4 shows the balance of energy in the system. According to simple theoretical considerations, half of the released potential energy is radiated away, while half remains in the mass, raising its temperature. The detailed properties of the solar material cause departures from this simple rule. Note that the total energy is accurately balanced at zero in our calculations. When the main sequence is reached, the rate that energy is radiated equals the thermonuclear energy production rate.

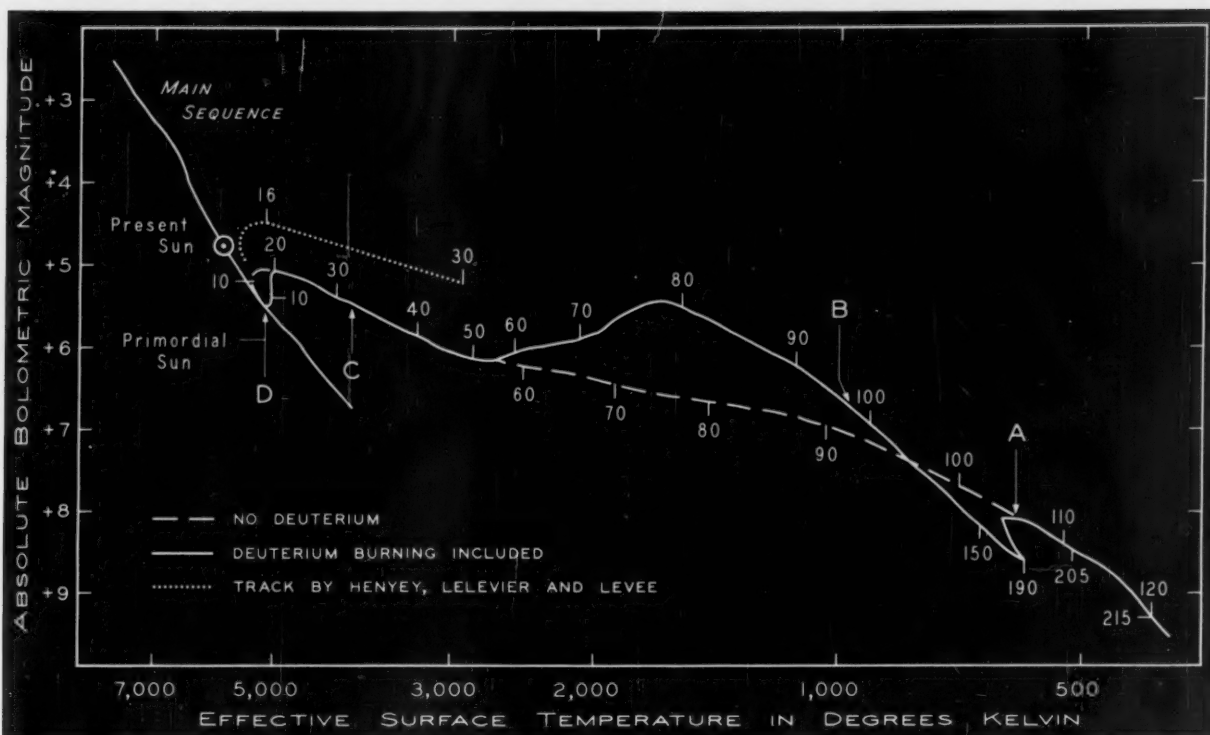


Fig. 5. Evolutionary tracks of three different model suns plotted on a theoretical Hertzsprung-Russell diagram. The tracks are labeled in millions of years before the main sequence is reached, matching Fig. 4. The letters A, B, C, and D correspond to those at the top of Fig. 4 and to the table of physical properties on page 256.

The evolutionary history of the sun is shown in Fig. 5, which is a theoretical H-R diagram. During their contraction, the solar models trace paths from the lower right corner (the domain of faint, very cool stars) to the observed zero-age main sequence.

Also plotted is the track computed by Henyey, LeLevier, and Levee. Though their calculations did not consider the deuterium reactions and are outdated by improved opacities and energy-generation laws, the general shape of their curve is still valid.

The sudden collapse of the deuterium model, after almost all of this constituent is burned, causes a temporary brightening when the surface temperature is between 1,000° and 3,000° K. Later, for the same model, burning of He³ causes a tempo-

rary pause in the contraction, and hence the drop in luminosity, 20 million years before the main sequence is reached. For-

tunately, both new evolutionary tracks end on the zero-age main sequence, and this fact gives confidence to our under-

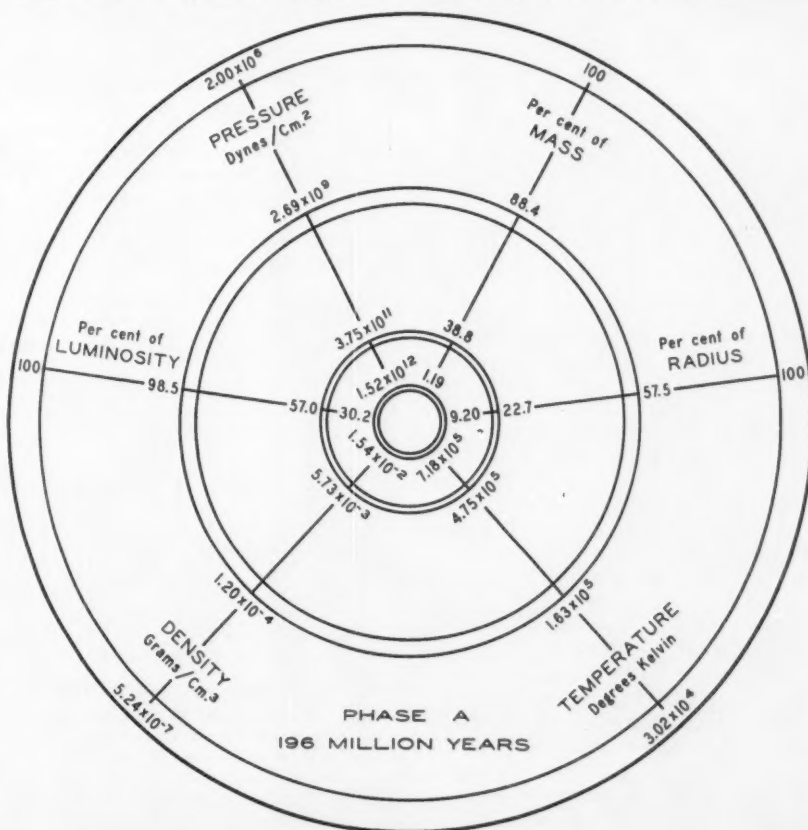


Fig. 6. This is the manner in which the solar mass of 1.99×10^{33} grams was divided into concentric shells, the four representative shells of Fig. 4 being shown here for the deuterium model at phase A, not long after the start of contraction. Temperatures, densities, and pressures are for the mid-points of the four shells; percentages of mass, radius, and luminosity are for their outer boundaries. The full radius is 1.25×10^{12} centimeters and the total luminosity is 1.78×10^{32} ergs per second. Values on this chart are those in the table on page 256, where the same data are given for the subsequent phases, B, C, and D.



Fig. 7 (left). Energy was produced by three different thermonuclear processes in the model sun. Scalloped lines indicate where deuterium burning took place. Hydrogen burning to He^3 and the complete chain to He^4 are shown by broken and solid hatching, respectively. The segments representing the model at times B, C, and D have been enlarged to match the size at A.

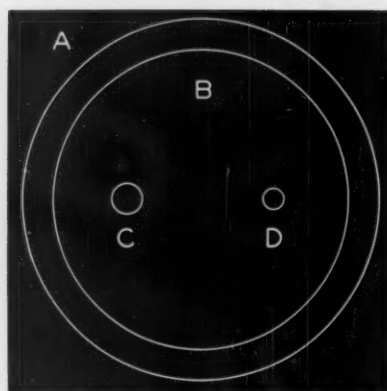


Fig. 8 (right). Relative model sizes at the four selected stages of evolution. They correspond to 196, 98, 32, and 0 million years before the main-sequence phase.

standing at the present time of the sun's evolution.

The table and Figs. 6-8 show in more detail the structure in the deuterium-burning model at four different phases, indicated by A, B, C, and D. In the table and Fig. 6, mass, radius, and luminosity

How close to reality are our results? If the assumed composition or the energy-generation laws we used are not correct, then our evolutionary track has not reached the main sequence at the position of the actual primordial sun. It is believed that about five billion years have

been required for the primordial sun to evolve up the main sequence to the present sun's position, whereas the evolution time for our model turns out to be more than twice as long as that.

It is important to realize that spectroscopic observations of the real sun have given us the composition for all important elements except helium. Current studies of the primordial sun's probable evolution, using the presently adopted energy-generation laws, indicate that a somewhat larger helium abundance than the one we used would have been more appropriate;

INTERNAL STRUCTURE OF THE FOUR REPRESENTATIVE MODELS

POSITION	MASS				TEMPERATURE (Degrees Kelvin)				DENSITY (Grams/Cm. ³)			
	A, B, C, D				A	B	C	D	A	B	C	D
Zone 1	0.046%				8.02×10^5	1.14×10^6	8.76×10^6	1.31×10^7	1.78×10^{-2}	1.52×10^{-3}	4.42×10^1	8.26×10^1
Zone 6	1.19				7.18×10^5	1.06×10^6	8.20×10^6	1.18×10^7	1.54×10^{-2}	1.12×10^{-3}	3.46×10^1	7.07×10^1
Zone 14	38.8				4.75×10^5	8.29×10^5	5.93×10^6	7.92×10^6	5.73×10^{-3}	2.13×10^{-3}	1.02×10^1	2.78×10^1
Zone 22	88.4				1.63×10^5	2.49×10^5	1.94×10^6	2.79×10^6	1.20×10^{-4}	2.63×10^{-4}	2.14×10^{-1}	7.00×10^{-1}
Zone 30	100.0				3.02×10^4	4.30×10^4	3.70×10^5	3.14×10^5	5.24×10^{-7}	8.74×10^{-7}	8.58×10^{-4}	7.11×10^{-3}
POSITION	RADIUS				LUMINOSITY				PRESSURE (Dynes/Cm. ²)			
	A	B	C	D	A	B	C	D	A	B	C	D
Zone 1	1.60%	0.96%	1.43%	1.91%	6.55%	0.087%	0.061%	0.48%	1.98×10^{12}	2.38×10^{12}	5.46×10^{16}	1.53×10^{17}
Zone 6	9.20	5.76	8.42	11.1	30.2	15.7	9.76	40.5	1.52×10^{12}	1.63×10^{12}	3.99×10^{16}	1.18×10^{17}
Zone 14	22.7	16.8	22.2	27.1	57.0	53.8	65.0	96.6	3.75×10^{11}	2.44×10^{12}	8.37×10^{15}	3.09×10^{16}
Zone 22	57.5	51.2	57.8	65.0	98.5	97.5	97.9	100.0	2.69×10^9	9.08×10^9	5.73×10^{13}	2.97×10^{14}
Zone 30	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	2.00×10^6	4.83×10^6	4.29×10^{10}	3.08×10^{11}

percentages refer to the outer edges of the shells indicated, while temperature, density, and pressure values are given for points midway between the interfaces of each shell. Temperatures are in degrees Kelvin, densities in grams per cubic centimeter, and pressures in dynes per square centimeter.

Additional information on temperature and density variations in model D is given in Fig. 9. These plots agree well with the previous work of Sears, if allowance is made for our more recent data for opacity and energy production. Both a small core and an extensive envelope exist in which almost all the energy is carried by convection. The temperature at the bottom of the envelope is 1.3 million degrees. The convective core shrinks and disappears after a few million years, as the model evolves up the main sequence, slowly changing its composition.

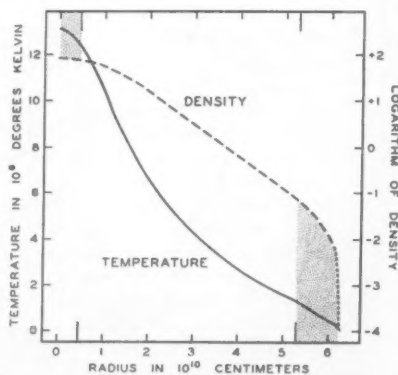


Fig. 9. Temperature and density inside the primordial sun. The shaded areas indicate the convective core, containing less than one per cent of the total mass, and the convective envelope. The dotted ending of the density curve is an extrapolation.

therefore, we are doing further work on this problem to obtain a more precise picture of early solar evolution.

IGY REPORT ON AURORAS

Fifteen papers giving the results of millions of visual aurora observations made during the International Geophysical Year have recently been published by the National Academy of Sciences. These statistical studies of auroras deal with the location of the auroral zone, relations to magnetic storms, radio interference, color, and motion.

Edited by C. W. Gartlein and G. C. Sprague of Cornell University, the papers are available as IGY General Report No. 12, "Report on IGY Visual Auroral Observations," and may be purchased for \$1.00 from the Publications Office, National Academy of Sciences, Washington 25, D. C.

OBSERVING THE SATELLITES

EXPLORER X

MORE than 60 hours of valuable measurements of magnetic fields in space, and of charged particles at distances out to some 112,500 miles from Earth, were gathered during the highly successful flight of Explorer X. This probe was sent up for the National Aeronautics and Space Administration from Cape Canaveral, Florida, on March 25th at about 15:17 Universal time.

A Douglas-launched Thor-Delta vehicle placed the 78-pound payload into orbit. The firing routine for Delta that was described in this department for October, 1960, page 200, was changed by shortening the coasting period after second-stage burnout to about 40 seconds. Thus the payload had attained an altitude of only some 110 miles when it was injected into orbit, about 890 miles downrange. The injection velocity was 24,266 miles per hour, about 1.7 per cent short of the speed for escape from the earth's gravitational field. In this case escape was not needed, for the specific purpose of the flight was to probe the so-called cislunar region, where the earth's magnetic field apparently merges with that of interplanetary space.

Earlier results from Pioneers I and V and Explorer VI had given tantalizing glimpses of some phenomena in this region. For example, magnetic-field measurements indicated a vast ring current, composed of ions carrying some 5,000,000 amperes westward within a doughnut-shaped path lying between 25,000 and 40,000 miles from Earth. Farther out, between 35,000 and 60,000 miles, large fluctuations in field strength have given evidence of hydromagnetic waves.

This region of magnetic activity may lie just within a suspected boundary between the terrestrial and interplanetary fields; cosmic-ray data from Pioneer IV are consistent with this hypothesis. Beyond some 60,000 miles, field fluctuations

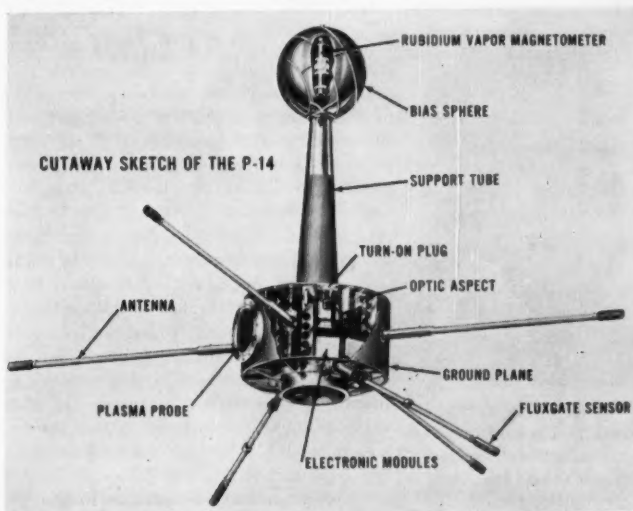
drop tenfold, and there is evidence for a steady interplanetary field, whose lines of force may be nearly perpendicular to the plane of the earth's orbit.

Study of these magnetic fields is essential to understanding the motions of charged particles in space. The Van Allen belts of trapped high-energy ions that shuttle back and forth along geomagnetic lines of force are somehow related to the "solar wind" of protons, but the problem is far from solved.

Explorer X was designed to furnish more accurate measurements of the magnetic field and of the motions of charged particles. Because rapid fluctuations in these phenomena are of great theoretical importance, it was essential to transmit data to earth continuously. This meant great power consumption, about 18 watts, requiring the use of 35 pounds of silver-zinc batteries, instead of solar cells.

To interpret the observations made by Explorer X's magnetometers and plasma probe, the vehicle's orientation in space had to be known. This was ascertained by optical sensors which detected sun, moon, and earth positions with respect to the vehicle. Operation of the sensors limited the date and time of launching. For instance, the moon could not be new, as it would then be a dark body nearly in line with the sun.

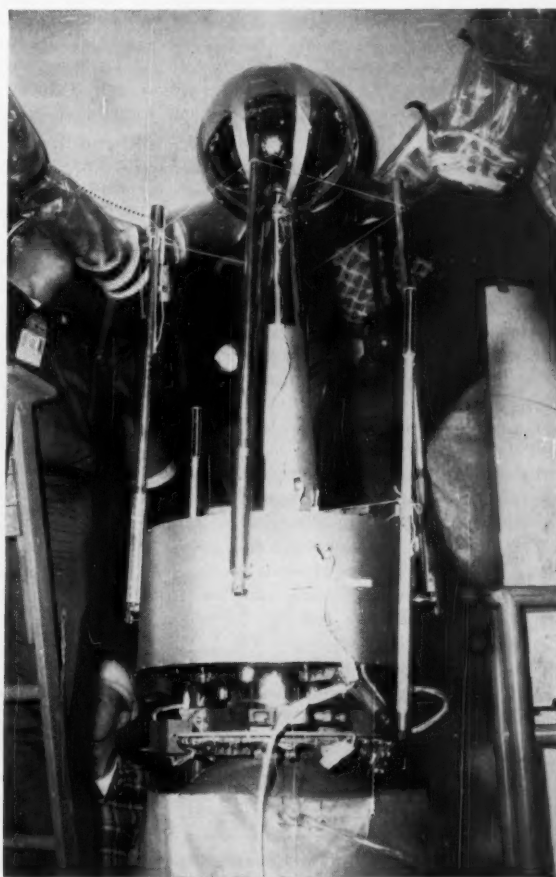
We see at the right the payload of Explorer X in place on the three-stage Thor-Delta launch vehicle (pictured on the cover of this issue). Below are sketched the principal parts of the probe assembly. National Aeronautics and Space Administration photographs.

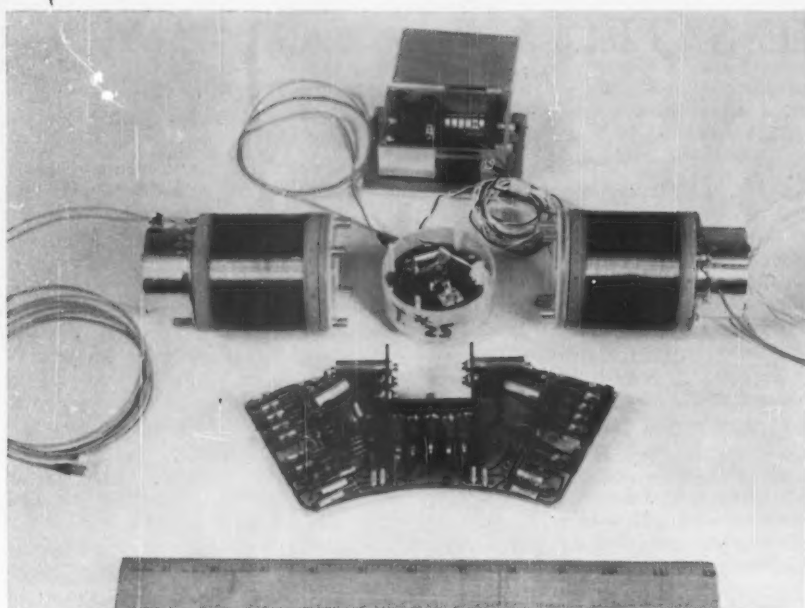


Furthermore, the firing had to be timed so that radio noise from the sun would not later flood the ground antennas receiving data from the vehicle. Its topmost sphere must be in continual sunlight, in order to maintain an intended temperature of 40° centigrade. These and other requirements restricted the permissible time of firing to about 10 hours during a given month, spread out over some five days.

The plasma probe carried by the Explorer is more sensitive to protons of lower velocities than was any previous instrument sent into space by American scientists. As explained to the writer by H. S. Bridge and F. Scherb of Massachusetts Institute of Technology, it should be capable of measuring even low-energy streams of protons from the sun. In this experiment, the bulk velocity of the protons is believed to indicate the motion of the plasma as a whole; electrons are not measured for this purpose as any general drift they may have is more apt to be masked by their random individual thermal motions.

A round magnesium plate, mounted within a six-inch magnesium cup but insulated from it, serves as the collector of protons. In front of the plate are five wire screens. The one nearest the plate is negatively charged, to about -130 volts, in order to repel outward both those electrons that may enter the cup and those





The components of the rubidium-vapor magnetometer are displayed in this picture from NASA. The rubidium lamp is in the center, with a rubidium gas cell on each side of it. At the top is the oscillator for introducing an alternating current, and at the bottom the amplifier assembly.

generated within it by solar ultraviolet light. Beyond this grid is another, grounded to the surface of the vehicle, as is the outermost one. Between these grounded grids is a pair which serves to impress a modulating positive voltage upon the incoming protons, alternately checking and permitting their flow 1,500 times each second.

Thus, the collector has a 1,500-cycle alternating current superimposed upon its steady output. This current is measured, converted to a frequency deviation in the telemetry system, and radioed to the earth. Each screening voltage (6, 20, 80 volts for the inner alternating grid; 250, 1,000, 2,300 volts for the outer) is used for five seconds. Then the telemetry passes on to other experiments for about two minutes, after which it reports on plasma flux again, this time with the next screening voltage.

During each five-second measuring interval, Explorer X makes about nine rotations around its long axis, causing the measured proton flux to vary in a manner from which the direction of the plasma's motion can be deduced. With this equipment, proton currents as small as 10^{-12} ampere per square centimeter, and having motions as low as 100 miles per second, can be detected.

The rubidium-vapor magnetometer is a new device, lightweight, sensitive, and simple in operation though not in theory. Structurally, it consists of a rubidium-vapor lamp shining through polarizing screens and filters that transmit only a single wave length. The circularly polarized light is admitted to a pair of cells also filled with rubidium vapor. Each of

these absorption cells is backed by a silicon photoelectric detector, whose slowly oscillating output is amplified and then fed back to a coil surrounding the cell. If the feed-back amplifier has been properly designed, the frequency of this slow oscillation is directly proportional to the strength of the surrounding magnetic field.

The operation of this novel apparatus depends on well-established principles of quantum mechanics. Both the lamp and gas cell contain a single rubidium isotope, Rb-87. The filters pass photons of a particular frequency and polarization that will react only with certain rubidium atoms — specifically, those in the lower-energy magnetic substates of the ground



The plasma probe of Explorer X. The grids stretch across the dark circular opening, but are not visible in the reproduction. Massachusetts Institute of Technology photograph.

energy level. The ground level contains such substates because the spin axis of an atom is permitted to make only one of a few discrete angles with respect to the direction of an associated magnetic field (an effect that has been called the quantization of space). For brevity, we shall say that these atoms are in the "low-low" state.

When the selected light quanta react with low-low atoms in a gas cell, these are boosted to a higher energy level. An atom does not linger long in this energized state — in perhaps 10^{-7} second it falls back to the ground level. But the atom does not necessarily return to the substate from which it started; there is a fair probability that it may end in a higher magnetic substate, which we might call "low-high." By colliding with the walls of the vessel and thereby exchanging energy, low-high atoms eventually return to the low-low state. No matter in which manner an atom has come back to the low-low state, it may once more react with the incoming radiation, again being raised to the higher level with a fair chance of falling back to the low-high state.

Thus, as long as enough incoming photons are supplied, the more strongly light-absorbing magnetic substates become depopulated, and the less strongly absorbing ones are filled up. The operation of the device depends upon this greater transparency of the vapor after the low-low atoms are converted to the low-high state. The process we have described here was named *optical pumping* by A. Kastler, who introduced it a decade ago.

Optical pumping, then, tends to keep the ground-level rubidium atoms in their higher magnetic substates. Now, much as a spinning top interacts with the earth's gravitational field to precess in a slow circle, so the spinning atoms precess around magnetic lines of force. The frequency of this *Larmor precession* depends only upon the strength of the magnetic field and upon certain fundamental natural constants. For Rb-87 atoms, the Larmor frequency in cycles per second is $699,632 H$, where H is the field strength in gauss.

If electromagnetic energy at the Larmor frequency is applied to a field coil surrounding the gas cell, the optically pumped low-high atoms readily swing around to follow the field at this frequency, which is their natural rate of precession, and in so doing they change their orientation relative to the incoming beam of polarized light. In effect there is a "resonance" with the low-low state at the precession frequency. Thus, the intensity of the light transmitted through the gas cell varies periodically at this rate. The silicon photodetector responds to this variation by a changing photocurrent, which is amplified and used to energize the field coil.

In this way, the apparatus builds up

oscillations at the Larmor frequency which corresponds to the surrounding magnetic field. This absolute measurement of field strength in interplanetary space, therefore, can be directly telemetered to Earth, without further calibration.

The magnetometer flown in Explorer X was developed by Varian Associates, Palo Alto, California. Its amplifier responds with good fidelity in the range of frequencies for magnetic fields of 10 to 700 gammas. (One gamma is 10^{-8} gauss.)

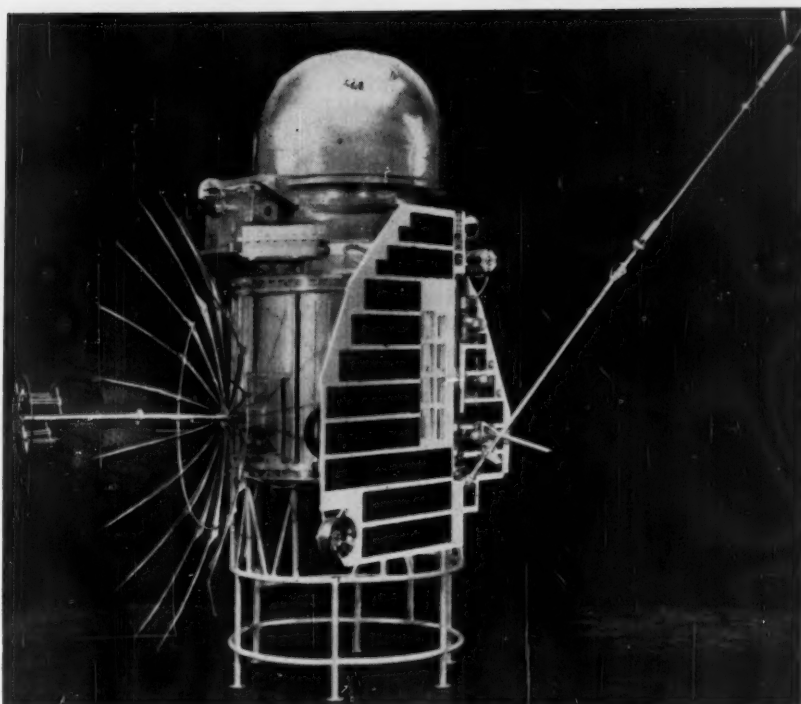
In the farther part of the Explorer's trajectory, however, fields much weaker than 10 gammas were considered likely. At this field strength the Larmor frequency is only 70 cycles per second, and to go much lower would demand good "bass response" from a tiny amplifier. This was not feasible, but an interesting solution was found.

The rubidium-vapor magnetometer is mounted in a 13-inch fiberglass sphere, which is surrounded by four parallel coils of wire. A current flowing through the coils generates a 10-gamma magnetic field, which combines vectorially with the earth's field. The 70-cycle frequency thus varies rhythmically as the probe spins on its axis. This permits detection and measurement of very weak fields — down to 0.1 gamma. Also, by relating the measured strength to the probe's orientation, the direction of the interplanetary field may be deduced.

Two years ago, Vanguard III carried aloft a proton-precession magnetometer, described in *SKY AND TELESCOPE* for November, 1959, page 12. But it required more power for its operation, and was not nearly as sensitive as the rubidium-vapor device.

Explorer X also has two fluxgate magnetometers, mounted at the ends of long arms, primarily to find the directions of weak fields. By combining measurements made with these two units at several positions in each rotation, a second means of measuring the total field strength is provided. These devices are calibrated in flight by means of small coils on the rods.

From Doppler data received by the



This photograph of the payload of the Soviet Venus probe shows some of the instrumentation designed to maintain the station in space and to relay information to Earth from the neighborhood of Venus. Courtesy Soviet Embassy.

Minitrack network and other stations, NASA has computed the path of the probe as a very elongated ellipse, with a perigee height of only about 110 miles. This is so low that a small error would drastically alter the anticipated drag; hence the lifetime of 1961 κ remains uncertain. Its period, 5,012.3 minutes or 3.4808 days, corresponds to an apogee height slightly more than 112,500 miles. The orbital inclination is 33.0 degrees.

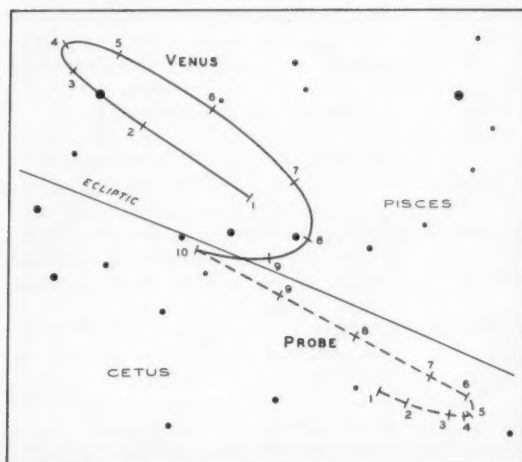
SOVIET VENUS PROBE

THE LAUNCHING of an interplanetary space station from Sputnik VIII was described here last month. Although much public interest was aroused by the Venus probe, few facts have been forth-

coming from the usual official sources.

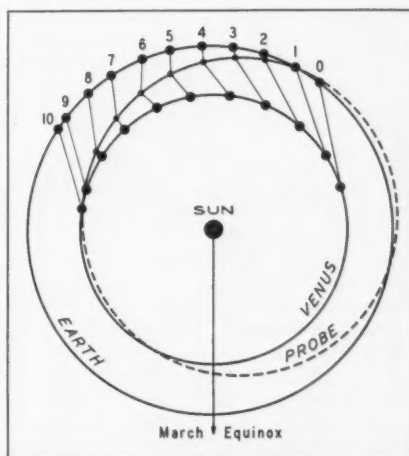
The picture above, which was recently released by the Soviet Embassy, shows the external appearance of the probe. The parabolic reflector at the left is made of wire mesh over an array of folding arms. This design makes it possible for the dish to be folded into a compact bundle at take-off. In order to feed the paraboloid, four small dipole antennas (extreme left) are mounted on a telescoping rod. When extended, as shown here, the rod holds the antennas at the focus of the reflector.

The black rectangles are solar cells, arranged on two vanes which unfold outward in order to present the maximum possible area to incoming sunlight. Located between these solar-cell vanes is



At the left is a chart of the paths of Venus and the Soviet probe projected on the celestial sphere. Part of the retrograde loop of Venus is shown prior to the encounter of the two bodies, supposed to occur about May 19-20.

The diagram at the right shows the orbits of Earth, Venus, and the probe. Their positions are given at approximately 10-day intervals, numbered to match the other chart. Diagrams courtesy Soviet Embassy.



an extensive group of instruments of undisclosed purpose. Projecting from this array is a long rod antenna — shown only half extended in the display photograph.

The white struts at the bottom of the picture are for mounting in the laboratory and not part of the final package orbited toward Venus.

The charts on page 259 depict the path of the interplanetary probe at different times during its flight. One of these diagrams shows the motion of the probe against the sky. In the other, the orbits of Earth, Venus, and the probe are projected onto the plane of the ecliptic, showing the geometrical relation of the three bodies at times corresponding to those on the sky chart.

Since no further word of this "artificial planet" has been released, despite the fact that it is expected to reach the neighborhood of Venus this month, it is presumed that Soviet scientists have been unable to re-establish radio contact, which was lost early in March.

SPUTNIKS IX AND X

THE Soviet Union launched its fourth and fifth "satellite spaceships" during March, and recovered each of them together with their animal passengers after brief orbital flights. Both ascents were undertaken to further "the design of the spaceship and of the equipment on board so as to ensure the necessary conditions

for the flight of man," according to Tass news agency.

The first of these vehicles was sent up from Russia on March 9th, evidently about 6 o'clock Universal time. Later the same day, its payload, which included a four-year-old female dog named Chernushka (Blackie), was recovered somewhere in Soviet territory. Other biological specimens carried were a guinea pig, a mouse, insects, and seeds. It is not clear whether they were brought back to earth in the cabin itself or, as in the previous successful recovery, inside a capsule ejected from the cabin before landing. Nor was it announced how long the spaceship remained in orbit around the earth.

Even fewer details were made public concerning the fifth payload in this series, launched and recovered on March 25th, this time with a dog named Zvezdochka (Little Star) as the chief passenger.

These spaceships each weighed about 4,700 kilograms (10,360 pounds), exclusive of the last stages of their rockets. Thus, they were only about 300 pounds heavier than 1960₂1 and 200 more than 1960₃1, the two previous Soviet spaceships. The first of the series, 1960₂1, was only slightly lighter. These figures suggest that the design of the Russian re-entry system is well standardized by now.

The great weight of the vehicles in orbit permits an outer shell thick enough to afford protection against meteoric impact, according to a Tass announcement

made soon after recovery of the fourth ship. This vehicle, called Sputnik IX here, or 1961₀1, orbited the earth at a height between about 110 and 155 miles, in a plane inclined 64.9 degrees to the earth's equator. Accompanying it in orbit and outlasting it by only about a day were two additional parts, 1961₀2, which was presumably the launching rocket, and unidentified 1961₀3. According to the National Aeronautics and Space Administration, they had anomalistic periods of 88.2 and 88.0 minutes, respectively. The perigee and apogee heights were 107 and 127 miles for ₀2, and both were approximately 116 miles for ₀3's nearly circular orbit.

The fifth "satellite spaceship," called Sputnik X or 1961₁1 here, had perigee and apogee heights of 110 and 153 miles, according to Radio Moscow, values corresponding to an anomalistic period of 88.7 minutes. The same figures apply to the unidentified part 1961₁3, according to information distributed by NASA, while the final rocket stage, 1961₁2, orbited in about the same period between 89 and 180 miles, approximately. The orbital inclinations for all three components were close to 65.0 degrees. Both ₁2 and ₁3 returned to the lower atmosphere on March 26th.

MARSHALL MELIN

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THIS YEAR'S CONVENTIONS

Attendance by American astronomers, both amateur and professional, at major meetings may reach an all-time record in 1961. The following gatherings are scheduled for the remainder of the year.

The Astronomical League holds its national convention June 30-July 3 at Detroit, Michigan. Regional meetings already definite are: North-Central, April 28-30 at Urbana, Illinois; Southeast, May 5-7, Chattanooga, Tennessee; Northeast, May 26-28, Rochester, New York; Mid-States, June 16-18, Fayette, Missouri; Northwest, June 17-18, at Wenatchee, Washington. The Great Lakes region's gathering will be part of the national convention on June 30-July 3. Definite plans have not been announced by the Middle-East, Southwest, and Mountain regions.

The Western Amateur Astronomers meet at Long Beach, California, on August 24-26. Both gatherings of the Association of Lunar and Planetary Observers will be held jointly with other groups: June 30-July 3 with the Astronomical League and August 24-26 with the Western Amateur Astronomers.

The American Association of Variable Star Observers, celebrating its 50th year, convenes twice, on May 26-27 at Ottawa, Canada, and on October 13-15 at Cambridge, Massachusetts.

Amateur telescope makers have their annual Stellafane get-together on August 12th at Springfield, Vermont.

For professional astronomers, the major event of the year is the triennial general assembly of the International Astronomical Union, at Berkeley, California, on August 15-24. During the preceding and following weeks, there will be symposia on double stars, space astronomy, galaxies, and the solar corona, at Berkeley, Pasadena, Santa Barbara, California, and Cloudcroft, New Mexico, respectively.

The American Astronomical Society holds its next meeting on the island of Nantucket, Massachusetts, on June 18-21. Its Christmas sessions are scheduled for Denver, Colorado, on December 27-30.

Both professional and amateur astronomers make up the Astronomical Society of the Pacific, whose meeting is to be at Los Angeles, California, June 12-14.

Information about individual meetings appears from time to time on the News Notes and Amateur Astronomer pages of SKY AND TELESCOPE.

CORRECTION

On page 201 of the April issue, Discoverer XX should have been called 1961₂, not 1960₂. The error was pointed out by Keith P. Hertzog, Allentown, Pennsylvania. Recently this satellite has divided into four parts.

NOVA SCUTI

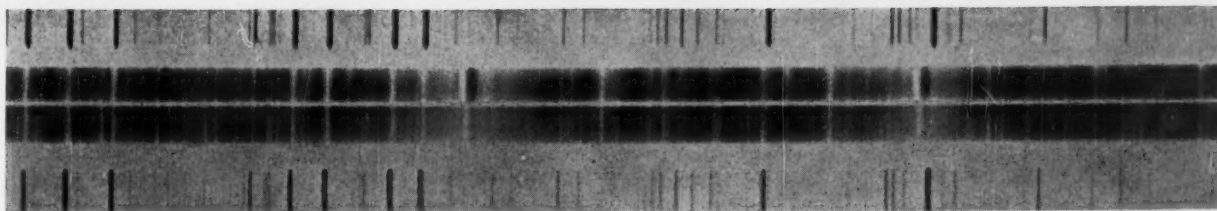
From spectrum photographs taken last year at Warner and Swasey Observatory, J. J. Nassau and C. B. Stephenson have discovered a faint nova in the constellation Scutum, at 18^h 31^m.9, -12° 58' (1950 co-ordinates). Their objective-prism plates of July 15, 1960, show a 13th-magnitude object, absent on earlier photographs, having a spectrum like that of Nova Herculis 1960 two months after maximum brightness. By now the nova has presumably faded to beyond the reach of all but very large telescopes.

The Ohio astronomers reported their find in *Harvard Announcement Card* 1525, dated March 24, 1961. This is presumably the same nova independently discovered by M. Savelyeva in Russia, as described last month, page 212.

SATURN RADIO OBSERVATIONS

Saturn has joined the list of planets that have been observed at radio wave lengths. In the British journal *Nature*, a team of Michigan radio astronomers report detection of 3.45-centimeter radiation from the planet.

Fourteen drift curves were taken on two occasions with the Portage Lake 85-foot radio telescope and ruby maser. They yielded a peak antenna temperature of 0°.095 Kelvin, corresponding to a source temperature of about 100° K.



Negative prints of the author's spectra of Eta Geminorum. The M-star (top) and the G-star (bottom) were recorded in 32- and 78-minute exposures made on October 5, 1958, and December 16, 1959, respectively. In both spectra, many neutral iron lines nearly match the iron comparison spectrum. The strong (black) emission lines located $2\frac{1}{2}$ and $5\frac{1}{2}$ inches from the left are the K and H lines of ionized calcium. Notice the intense absorption feature just to the left (blue) side of each one. The two strongest absorption lines between K and H are due to neutral aluminum. The dispersion in these enlargements is about $\frac{1}{2}$ angstrom per millimeter. Illustrations from Mount Wilson and Palomar Observatories.

The Triple System of Eta Geminorum

ARMIN J. DEUTSCH, *Mount Wilson and Palomar Observatories*

IN the February issue of this magazine, Walter Scott Houston called attention to the fine visual binary Eta Geminorum, and gave a diagram showing the orbital motion during the 80 years since S. W. Burnham discovered its duplicity. The primary star is an M3 giant, and the secondary a G8 giant which is three or four magnitudes fainter. The system is a notable one for several reasons.

In the first place, the M star is a well-known semiregular variable. Discovered by J. F. J. Schmidt in 1844, the light variation has a mean period of 233 days. The brightness at minimum shows rather unusual differences from cycle to cycle.

In the second place, D. B. McLaughlin and Suzanne Van Dijke have found the M star to be a spectroscopic binary, with a period of 8.2 years. These authors suggested that careful astrometric observations might reveal the angular motion of the M star in this short-period orbit. They also noted the possibility that the spectroscopic pair is an eclipsing binary. Acting on this suggestion, H. van Schewick found that faint minima systematically recur near the same phase of the eight-year spectroscopic orbit, and can be explained by supposing that the M star is eclipsed at these times.

Among the 14,566 variable stars in the most recent catalogue of B. V. Kukarkin and P. P. Parenago, Eta Geminorum is therefore one of only three stars that are listed as both eclipsing binaries and intrinsic variables. If this classification is correct, the close pair must be a very remarkable one. To satisfy the observations, the invisible star would have to be fainter than the M3 primary and later in spectral type. A normal giant star of type M5 or M6 would satisfy these requirements. Giant M stars are so large that these two would be nearly in contact with each other.

At Mount Wilson and Palomar Observatories, recent spectroscopic observa-

tions have now proved that all three stars are enveloped in an enormous cloud of cold gas. The pair of spectra above illustrates some of the evidence for this conclusion. The upper strip is a negative enlargement of the near ultraviolet spectrum of the M3 star; the lower strip shows the same part of the spectrum of the G8 visual companion. The original spectrograms have a dispersion of 10 angstroms per millimeter. They were obtained at the coude focus of the 200-inch telescope, the lower one on a night of extraordinarily good seeing. It is only under these conditions that we can obtain a spectrogram of the faint G star that is not seriously contaminated by the light of the much brighter M star only 1.5 seconds of arc away.

The two strongest lines in each of these spectrograms are the Fraunhofer lines H and K of ionized calcium. They have strong emission components, and sharp, deep absorption cores on their short wave length edges. In the spectra of late-type stars, emission lines are usually seen at the centers of the H and K absorption lines, and are attributed to the chromospheres of these stars. The deep absorption cores are also common

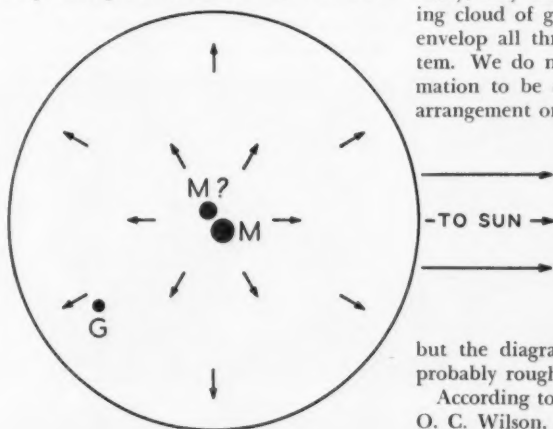
in the spectra of M giants. But they virtually never are seen in G stars like the visual companion of Eta Geminorum.

To help assess the significance of these unusual spectrum lines, let us consider the radial velocities that have been found from the Doppler effect in the spectra, as given in the table. Our coude spectrograms show that the M star changes its radial velocity with an eight-year period, much as McLaughlin and Miss Van Dijke found it to do. The center of mass of the close pair is receding from the sun at a speed of 18 kilometers per second, which is the mean velocity of the M star. Meanwhile, the G star has a radial velocity of +16 kilometers per second, slightly different from the first entry in the table because of the motion in the long-period orbit of the visual pair.

RADIAL VELOCITIES IN ETA GEMINORUM (Kilometers per second)

Mean of M star (visual primary)	+18
G star (visual secondary)	+16
H and K cores in M star	-9
H and K cores in G star	+11

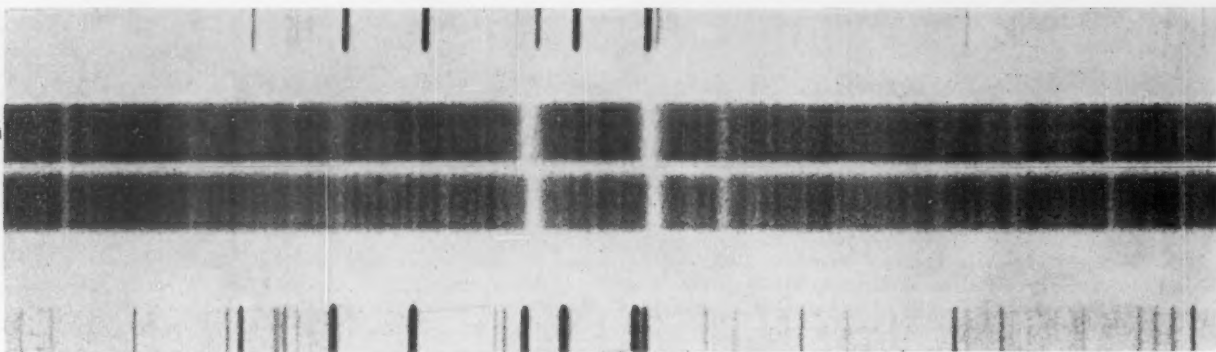
The deep absorption cores at the H and K lines indicate constant radial velocity; they must originate in an expanding cloud of gas that is large enough to envelop all three of the stars in the system. We do not yet have enough information to be certain of the geometrical arrangement or dimensions of the system,



A schematic diagram of Eta Geminorum. Short arrows indicate outward flow of cool gas. The effects of the unseen companion (M?) are illustrated in the spectra on the next page.

but the diagram shows a model that is probably roughly correct in its essentials.

According to a recent determination by O. C. Wilson, the distance to Eta Gemi-



The primary of Eta Geminorum shows broadened and washed-out spectral lines (top) compared to those of a normal M-type star, Mu Geminorum (bottom). The dispersion in these enlargements of plates taken October 3, 1960, is about one-third angstrom per millimeter. The strong absorption lines in the center are the sodium D lines. Just right of them and at the far left are two titanium lines. Exposure times were five minutes for Eta and $1\frac{1}{2}$ for Mu.

norum is about 100 parsecs (a little over 300 light-years). The projected separation of the visual pair is 150 astronomical units, and the true separation may appreciably exceed this amount if the G star lies a little nearer or farther from the sun than does the M star. The gas cloud responsible for the H and K cores is therefore at least 300 astronomical units in diameter, and it is expanding at a speed of $18 + 9 = 27$ kilometers per second. Along the line of sight to the G star, the expansion velocity is only $18 - 11 = 7$ kilometers per second because of geometrical effects.

The M stars in this system are among the largest stars known, with diameters of several hundred times that of the sun. Nevertheless, their dimensions are shown disproportionately large in the diagram, relative to the diameter of the circumstellar envelope. Similarly, the separation of the close pair is drawn out of scale. But the diagram does show how all three stars lie within a common cloud of outflowing gas.

During the last few years, the evidence has multiplied that similar expanding envelopes of cold gas are to be found around all M giants and supergiants. That this must be the case is indicated by the telltale deep absorption cores at the Fraunhofer H and K lines — abnormal features which appear in the spectra of all these M stars. But only in one other case has it so far proved possible to establish directly that the expanding envelope is many times larger than the star that produces it.

The well-known visual binary Alpha Herculis is the other example of this kind, closely resembling Eta Geminorum in several ways. Thus, the visual pair in Alpha Herculis comprises a luminous M5 giant and a G0 giant. There is also an invisible third star in the system. But in Alpha Herculis the third star is a close companion of the visual secondary, the G-type giant. Otto Struve gave a detailed description of Alpha Herculis in *SKY AND TELESCOPE* for April, 1956, page 252.

Evidently all the M giant stars eject

matter into space through envelopes like those around Alpha Herculis and Eta Geminorum. The physical laws that govern these massive outflows are still not understood; from the point of view of cosmical gas dynamics they continue to pose a fascinating problem. In addition, it is clear that the process of mass ejection plays an important role in stellar evolution. Indeed, there is a strong likelihood that the quiet and unobtrusive flows from late-type giants are responsible for providing the interstellar medium with much more mass than all the novae and other explosive stars together can contribute.

To return to Eta Geminorum, we may ask whether there is any hope of seeing the third star in the system, the object which van Schewick claimed to produce an eclipse every eight years. To the present time, there has been no certain observation of light from this body. However, many of the spectrum lines of the visual primary do seem rather shallower and more diffuse than is usual in an M3

giant, as though they might be blended with the Doppler-shifted lines of another, fainter spectrum of similar type. Some of these effects can be seen in the weaker features in the spectra above.

Here the visual primary of Eta Geminorum is compared with the standard star Mu Geminorum, which has the same spectral type. In addition to the small difference in contrast of the weaker spectrum lines, there is obviously a large difference between the two spectra at the D lines, the strong pair of sodium. Probably most of this difference comes from extra absorption by the unusually massive circumstellar envelope of Eta Geminorum. But the D lines do not have quite the usual character of circumstellar lines, and the possibility remains that part of the difference is due to sodium lines in the hitherto invisible third star. If this is so, the composite D lines should change in their structure as the visual primary moves on around its eight-year orbit. Clearly, Eta Geminorum will be an exciting object to observe for many years.

LETTERS

Sir:

I have often noticed that the stars in Coma Berenices with Flamsteed numbers 18, 21, and 22 form with a fourth fainter star a configuration strikingly like the Southern Cross. It is readily picked out with 6x30 binoculars or a small telescope at low power, being located approximately at right ascension $12^h 30^m$, declination $+24^\circ$. The cross lies on its side, as shown in the Skalnate Pleso *Atlas of the Heavens* and in the Harvard photograph on page 331 of the April, 1960, issue.

RICHARD A. KEEN
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Sir:

There is a simple way to increase the usefulness of the sidereal time scale that runs down the center of the Graphic Time Table of the Heavens, published by the Maryland Academy of Sciences (*SKY AND TELESCOPE*, page 34, January,

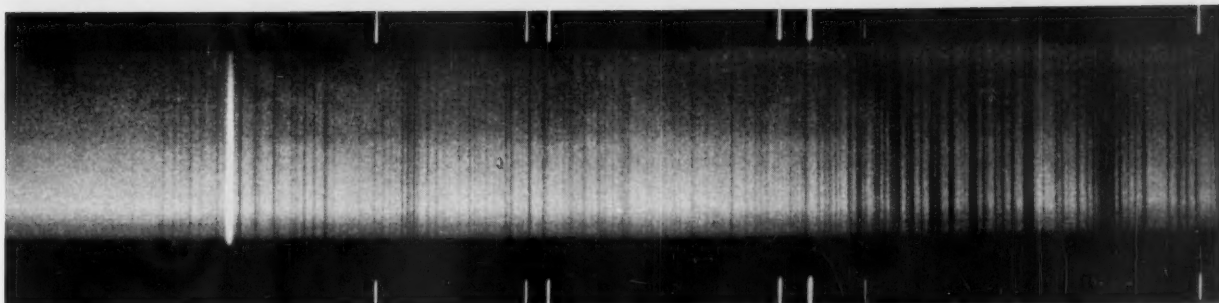
1961). It enables one to find the local sidereal time for any given standard time.

First locate the point on the chart corresponding to the standard time. This is done by changing the standard to local mean time by applying the correction for the observer's locality but with the plus or minus sign reversed. Find the resulting point on the chart by using the date and time scales and draw a line through the point parallel to the straight line showing the transit time of any fixed celestial object. The intersection of the drawn line with the sidereal scale gives the time sought.

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DAMAGED MARCH ISSUES

Letters from Canadian subscribers indicate that many copies of the March, 1961, issue of *SKY AND TELESCOPE* were damaged when delivered. These and all other copies received in unsatisfactory condition will be replaced upon request.



The red and infrared spectrum of the corona above the sun's south pole. At the left is a bright emission line of wave length 7891 angstroms, produced by iron atoms ionized 10 times at the high coronal temperature. Superimposed on the continuous background are dark absorption lines produced in the earth's atmosphere. Bright lines at top and bottom are from a laboratory spectrum and provide a wave-length scale. Haute Provence Observatory photograph.

Further February Eclipse Observations

DONALD H. MENZEL, *Harvard College Observatory*

LAST MONTH I told the experiences of astronomers from several countries who came to Imperia, on the Italian Riviera, to observe the total eclipse of the sun on February 15, 1961. The path of totality crossed southern France, northern Italy, and the Balkans, over a thickly populated and easily accessible region, where weather conditions on the whole turned out far more favorably than expected.

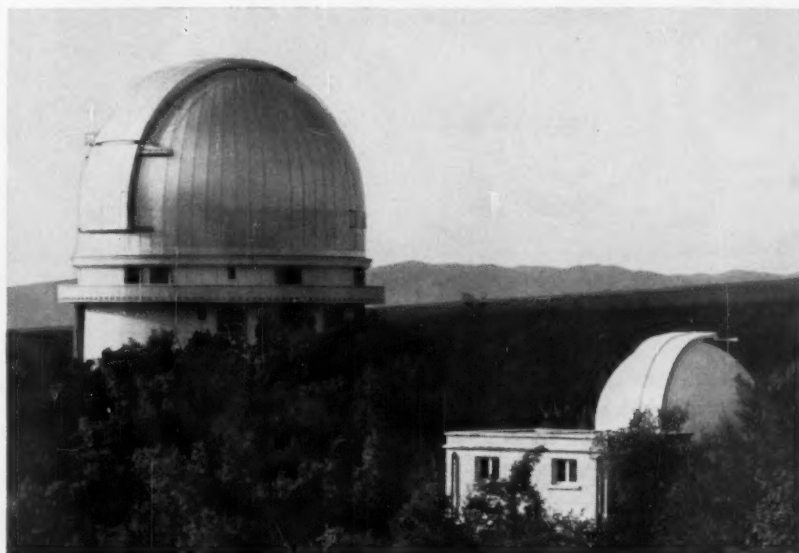
These circumstances made this eclipse one of the most extensively observed on record. Here is a summary of some of the studies made by other astronomers, following the shadow track from France, where the eclipse occurred early in the morning, eastward to Romania.

By good fortune, the well-equipped and modern Haute Provence Observatory at St. Michel, France, lay close to the central line. Most French observers selected this site. C. Fehrenbach (Haute Provence) and G. Wlérick (Meudon Observatory) used the 76-inch reflector to photograph the spectrum of the corona with a slit set radially above the south pole of the sun. They recorded wave lengths from 5800 angstroms in the yellow to 8800 angstroms in the infrared, at a dispersion of 19.4 ang-

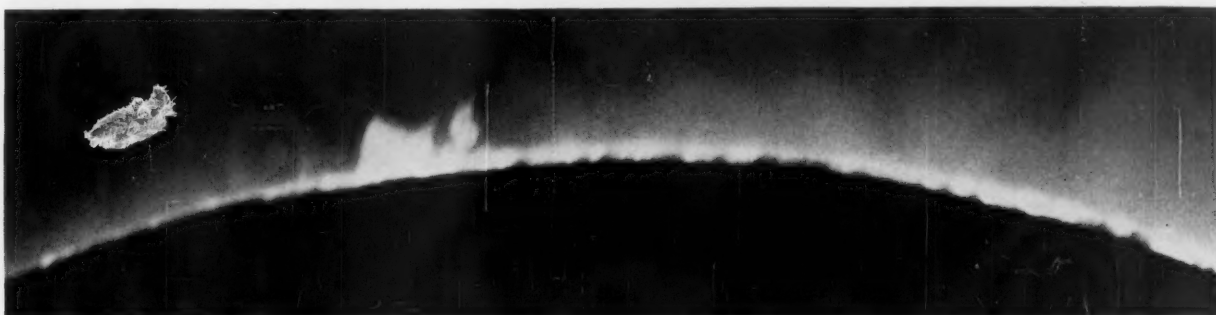
stroms per millimeter (spectrum above).

In addition, D. Chalonge from Paris employed the 32-inch reflector to observe

the spectrum of the polar corona. Both programs examined the coronal emission lines for possible polarization, suspected



A scene in southern France's Haute Provence, where the shadow of the moon passed on February 15th. At the left is the 76-inch reflector's dome, and that of the 16-inch objective-prism telescope appears at the right.



The sun's brilliant chromosphere and prominences and the roughness of the moon's edge are all recorded in this large-scale picture. Jean Bigay used a red filter with the 47-inch reflector of Haute Provence Observatory.



With the 47-inch reflector (focal length about 23½ feet), Jean Bigay took this very short exposure during totality. Several brilliant prominences appear, together with filaments of the innermost corona. Haute Provence Observatory photograph.

in the past but never proven. Although the observations were successful, analysis will require considerable time.

Also at Haute Provence, Jean Bigay from Lyons photographed the corona in red light, with the 47-inch reflector. R. Dumont, Bordeaux Observatory, employed a 24-inch telescope to measure photoelectrically the coronal brightness at different distances from the sun, while Jean Dufay of Lyons took an infrared photograph of the outer corona with a 12-inch Schmidt camera. The Haute Provence 6- and 15-inch objective-prism refractors were used to obtain flash spectra of the chromosphere at second and third contacts.

Assisted by Misses Bloch and Bretz, M. Laffineur from Paris obtained two remarkable pictures of the corona with a camera 12 feet long. A rotating sector near the focal plane reduced the great contrast between the bright inner corona and the

faint outer extensions. The resulting photographs suggest strongly how an eclipse appears to the eye. Page 195 of last month's issue shows one of Dr. Laffineur's pictures, and the other accompanies this article.

A large party of French amateurs went to Laragne, on the central line about 30 miles north of St. Michel. They enjoyed clear weather and carried out many observations. In the group was Jean Texereau, who made color pictures of the prominences and corona with a special telescope of his own design.

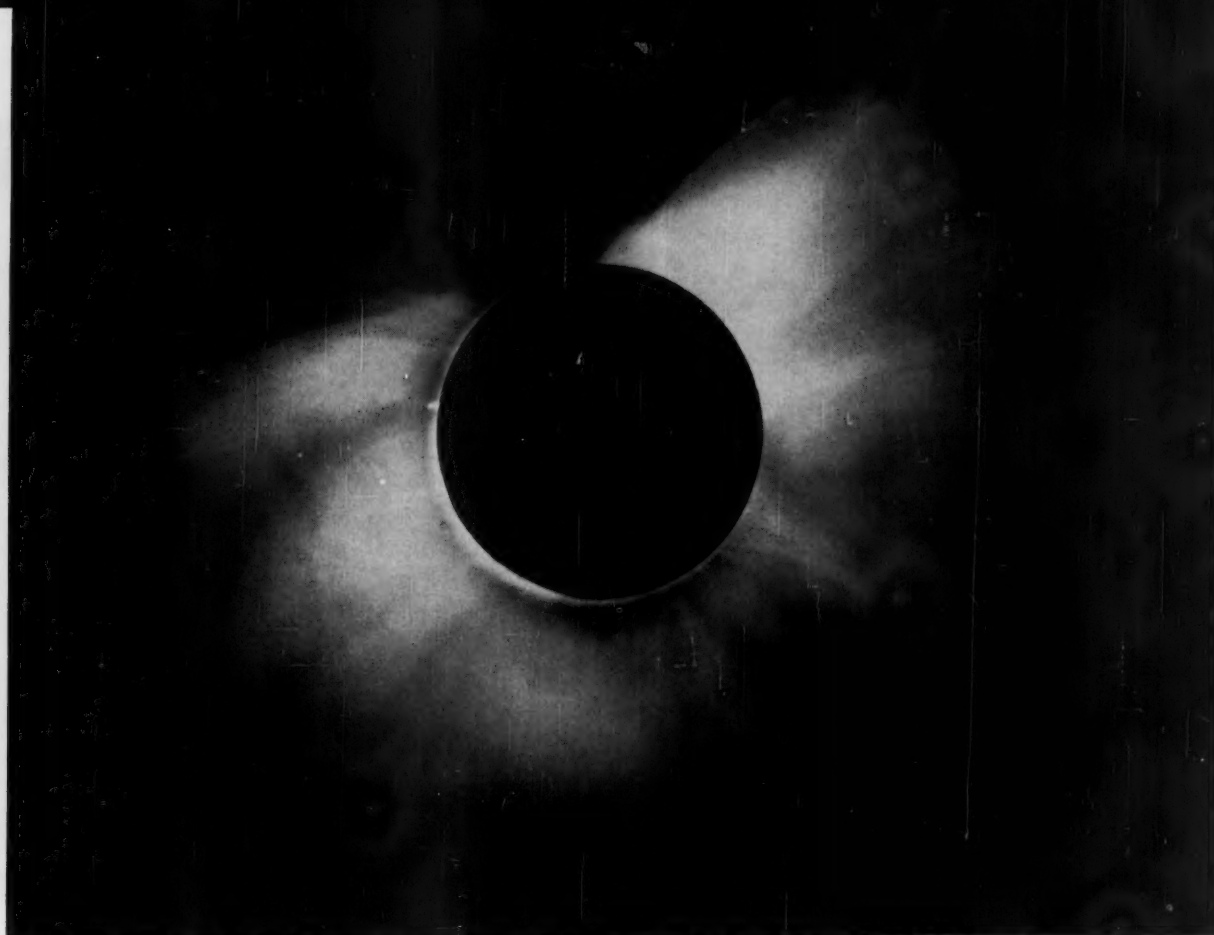
High in the Pyrenees mountains, Pic du Midi Observatory lay just outside the southern limit of the path of totality, 0.976 of the sun's diameter being obscured at maximum eclipse. Director J. Rösch took advantage of this circumstance to study the extreme edge of the sun, employing the moon's limb to measure the effects of seeing. A by-product of this pho-

tographic investigation was an accurate determination of the lunar profile, viewed in projection against the sun.

Pic du Midi astronomers A. Cachon, M. Gentili, and M. Trellis traveled to near Monaco, on the Mediterranean. They obtained coronal photographs in infrared light of about 8000 angstroms wave length, using a Zeiss camera of 28 inches focal length.

The German astronomer K. O. Kiepenheuer, who is director of the Fraunhofer Institute at Freiburg, went to Laiguera, Italy, a little village not far from Imperia. He had three small cameras for studying the structure of the inner corona, which he wished to correlate with surface features on the sun.

His party had a dictaphone on which to record their impressions, but during totality the observers were so preoccupied they forgot to talk! Later, when the recording was played back, it had one star-



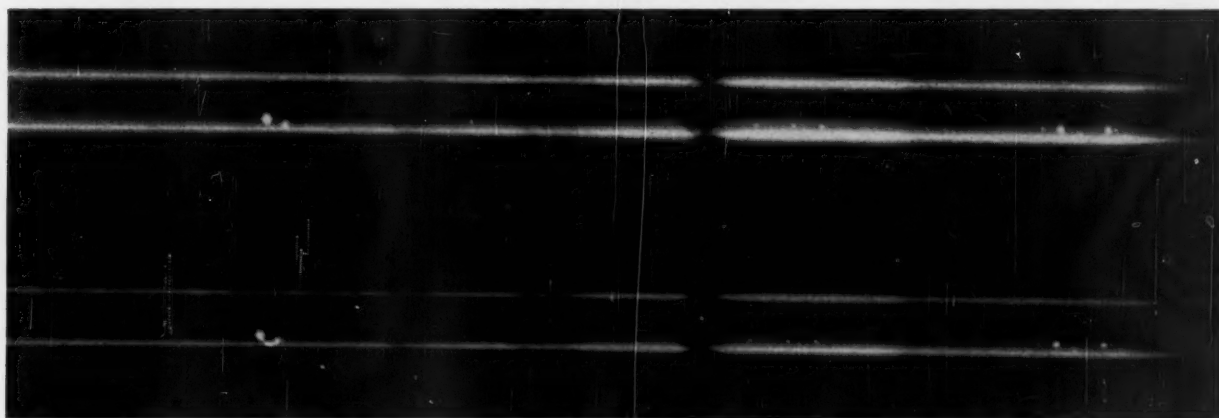
This unusual picture shows with remarkable clarity the characteristic internal structure of the "petals" that form the sun's corona. On the original negative some coronal streamers extend more than two solar diameters out from the limb. At Haute Provence, M. Laffineur, Miss M. Bloch, and Miss M. Bretz used a long-focus camera with a rotating sector for this 70-second exposure, which may be compared with their 10-second picture on page 195 last month. Courtesy M. Laffineur.

ting feature: Birds twittered distinctly in the background up to the beginning of totality, when these sounds stopped suddenly. Immediately after totality, the birds became active again. Dr. Kiepenheuer also mentioned that in the nearby town of Alasio the shops had corona photographs on sale within minutes after the eclipse, thanks to Polaroid cameras.

Observing in Italy is not unusual for Swedish astronomers, who maintain an astrophysical station on the Isle of Capri, near Naples. From there I have this information concerning the results of Yngve Ohman's eclipse observations at Imperia, where he had the apparatus pictured on page 193 last month. With a special slitless spectrograph, he recorded prominence

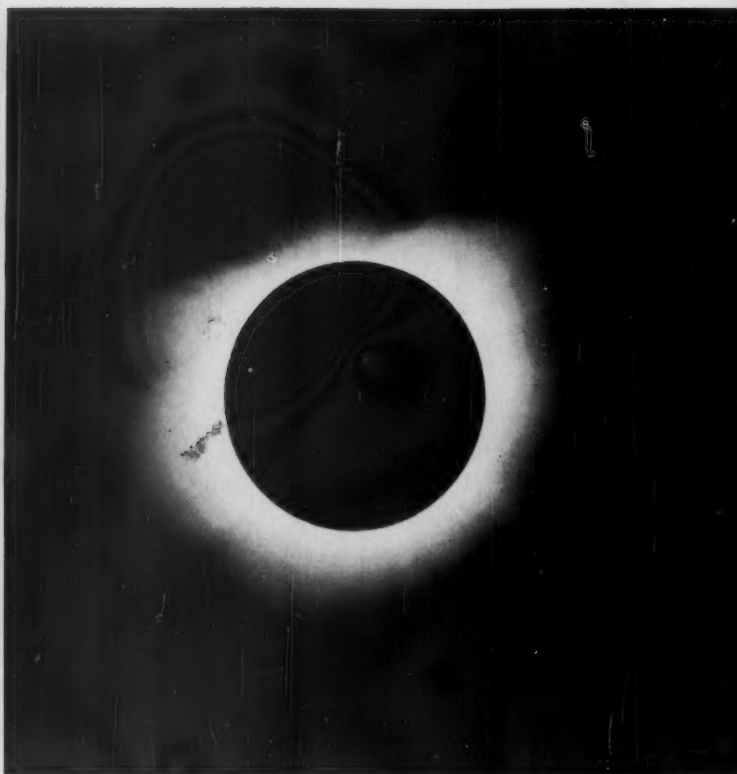
spectra in the red and near infrared. Two f/3.5 cameras were used, one of 5-cm. focus giving a linear dispersion of 270 angstroms per millimeter, the other of 13.5-cm. focus giving 100.

During the eclipse, three spectra were obtained with the low dispersion, four with the high dispersion, the exposure times ranging from one to 16 seconds;



Yngve Ohman obtained these spectra with a camera of 13.5-cm. focal length, the lower one exposed eight seconds, the upper twice as long. In each case, the strong continuous spectra are mainly produced by the corona at the east (lower) and west limbs of the sun. Measure from left to right to identify the following prominence emission features: $1\frac{1}{2}$ inches, hydrogen-alpha; $2\frac{3}{4}$, helium, 7065 angstroms; $4\frac{1}{2}$, oxygen, 7771; about $4\frac{3}{4}$ and $4\frac{7}{8}$, second-order calcium K and H; $5\frac{1}{2}$, probable Paschen continuum (east limb) extending leftward. At the far right lie three bright calcium lines in the infrared.

Courtesy Stockholm Observatory and the Swedish Astrophysical Station in Italy.



The sequence of pictures here and on the facing page was taken by M. de Saussure, University of Geneva. At left above is a 1/50-second exposure of second contact, with Bailey's beads just disappearing. At right is a 1/5-second picture of the middle corona, recorded with a yellow filter on Ilford film, the 50-mm. camera having an f/12 focal ratio.

the picture on page 265 shows emission lines of the prominence on the sun's northeast limb, with the strong image of hydrogen-alpha (6572 angstroms) on the left. The 7771 line from neutral oxygen was first detected by G. Righini, of Arcetri Observatory, during the eclipse in 1952. The three strong prominence lines toward the right, 8498, 8542, and 8662 angstroms, come from ionized calcium.

Professor Ohman believes that photometric analysis will reveal the hydrogen Paschen continuum extending toward wave lengths shorter than 8206 angstroms in the infrared. This prominence emission seems to be superimposed on the continuous coronal spectrum of the east limb. When these two exposures were made, the prominences at the west limb were still covered by the moon, so prominence lines or the hydrogen continuum do not contaminate its spectrum. Therefore, photometric comparison of these limb spectra should make possible a study of the Paschen continuum, if it is present in Dr. Ohman's records.

On Mt. Bignone near San Remo, a number of Italian observers gathered. With E. Bongiovanni of Bergamo were A. Musa, C. Recla, G. Turani, and two members of the Italian amateur radio society. Observers from Nuremberg in West Germany completed the group. They filmed the entire eclipse on Kodachrome, obtaining a series shot like that on page 202 of

the April number of *SKY AND TELESCOPE*.

Ancona, on the Adriatic coast of Italy, was another center for eclipse work, where F. Zagar from Milan took 1,400 exposures of the corona with a motion-picture camera, and Margherita Hack studied the polarization of the corona. Mt. Conero, near Ancona, was the site of one of six parties sent out by Rome's Monte Mario Observatory. There the well-known radio physicist Mario Cutolo, University of Naples, probed the ionosphere with radio-sounding devices. An undermodulated signal was projected directly upward, but after interacting with and bouncing off the ionosphere it returned to earth very strongly modulated. In fact, the modulation was so great that it almost destroyed the signal at times, but only during the eclipse. As yet unexplained, this interaction had been more or less expected by Dr. Cutolo on the basis of results from earlier experiments.

Also on Mt. Conero was W. Ducrey, with an expedition from the University of Geneva, Switzerland. He photographed the inner corona and prominences with an f/15 Gregory-Maksutov 6-inch telescope, using an unaluminized primary mirror. Mr. Ducrey points out the resemblance of this instrument to Sol Saul's 8-inch, pictured on page 117 in February's *SKY AND TELESCOPE*.

Arcetri Observatory, near Florence, is

another of the large institutions that was located within the path of totality. Arranging a program that would not be entirely frustrated by the expected bad weather, director Righini himself flew in a "flying boxcar," with the instruments pointing sunward through the plane's open rear door. In this way, he obtained photographs of the outer corona through a polarizing filter. Favorable weather on the ground enabled M. C. Ballario to secure the flash spectrum with the Arcetri tower telescope, and G. Godoli photographed the inner corona. An ultraviolet spectrograph was operated by Dora Russo, and M. Rigutti used a Fabry-Perot interferometer for the green coronal line. Alvaro Lepri photographed the hydrogen-alpha line with an interference filter.

Dr. V. Barocas, of the Jeremiah Horrocks Observatory in England, went to Arcetri. There he took flash spectra in the region 6000 to 9000 angstroms, with a dispersion of six angstroms per millimeter. He used a concave grating in an Eagle mounting, the exposures being made automatically at the rate of 50 per minute.

An American radio group, from the Air Force Cambridge Research Laboratories, was also at Arcetri Observatory. Led by John P. Castelli, they worked with Maurizio Piattelli, interchanging equipment and co-ordinating their studies un-



With a one-second exposure, Dr. de Saussure photographed the outer corona (left above), while a $1/50$ -second picture was made of the inner corona just as totality ended at third contact and the diamond ring began to form. He observed with other Swiss astronomers at Mt. Bignone, Italy, where totality lasted 118 seconds and the sun was 10 degrees high. University of Geneva photographs.

der an Air Force contract. Their $16\frac{1}{2}$ -foot antenna, pictured here, was used for reception near 23 centimeters, while the four-foot dish carried on the same mounting was for 3-cm. work. In preparation for

the eclipse, they observed the sun every morning for a week, and then continued the records for several days afterwards.

A site near Pisa was chosen by American radio astronomers from the University

of Texas. C. W. Tolbert's team measured 4.3-mm. radiation during the eclipse, using a 60-inch parabolic searchlight reflector as a collector, its beam width being 0.2 degree. During totality this radi-



G. E. Moreton of Lockheed Solar Observatory took these views of Arcetri with the author's Polaroid camera. The famous solar tower stands beyond the dome at left. In the right-hand picture, a $16\frac{1}{2}$ -foot dish used by American scientists to study solar emission at 23.7 centimeters carries a four-foot parabola for 3-cm. observations.

ation came from a source 0.5 degree in extent, with an effective emission temperature of 204° Kelvin, indicating that all the radiation was from the dark side of the moon and not from the sun's atmosphere.

The Texas scientists deduced that solar emission at the very short wave length of 4.3 millimeters is practically confined to the photosphere and possibly the chromosphere, with the corona making no significant contribution. Furthermore, the sun appeared to be of essentially uniform brightness at that wave length, except for some fluctuations of the observed emission temperature during partial eclipse when the solar disk was approximately half covered.

To provide a standard for the radio eclipse astronomers, G. Swarup, of Stanford University in California, has recently circulated contour maps of the sun's intensity about half a day before and after the time of mid-eclipse. These show the strongest radiation at 9.1 centimeters coming from the west limb.

Two other stations, at Macerata and Mt. Cimone, were manned by Roman astronomers for photographing the corona in yellow light. Jet-plane observations were successful (see pictures on page 194, April issue). R. Cialdea sent an

all-sky camera, such as those used for auroral observations, 15 miles high by balloon, hoping to measure the intensity, polarization, and extent of the corona at great distances from the sun.

Also at Macerata was Mario Fracastoro, director of Catania Observatory. He took color pictures of the corona, recorded coronal polarization, obtained spectra of the inner corona and prominences, and made objective-prism records of the flash spectrum by means of motion-picture cameras.

Dr. Heinz Haber, physicist from the University of California at Los Angeles, made his observations from a T-33 plane some 38,000 feet over Italy. He gave me a vivid description of the shadow of the moon as it swept over the earth below. Contrasting strongly with the brilliant snow of the Alps farther north, the shadow's darkness resembled that of a heavy rain squall. The shadow edge was not sharp, and had a definitely reddish tint. By flying at four-fifths the speed of sound, Dr. Haber and his party enjoyed some 20 seconds more of total eclipse than if they had stayed at one place on the ground.

Along the coast of Yugoslavia, weather was favorable, as reported on page 203 last month. Dr. C. de Jager, of Utrecht

Observatory, has given me some information about the Dutch expedition that went to the island of Brac, near the port of Split. This group's primary interest was the flash spectrum, which they recorded with a grating and 15-foot camera. Their pictures were taken in the fourth and fifth spectral orders, giving very high dispersion. A ciné camera, operated at 16 exposures per second, provided very high resolution in time, to record the rapid changes in intensities of metal lines near the times of contact. In addition, the Dutch astronomers used two coronal cameras, and carried out three-color photoelectric measurements of the intensity and shape of the corona.

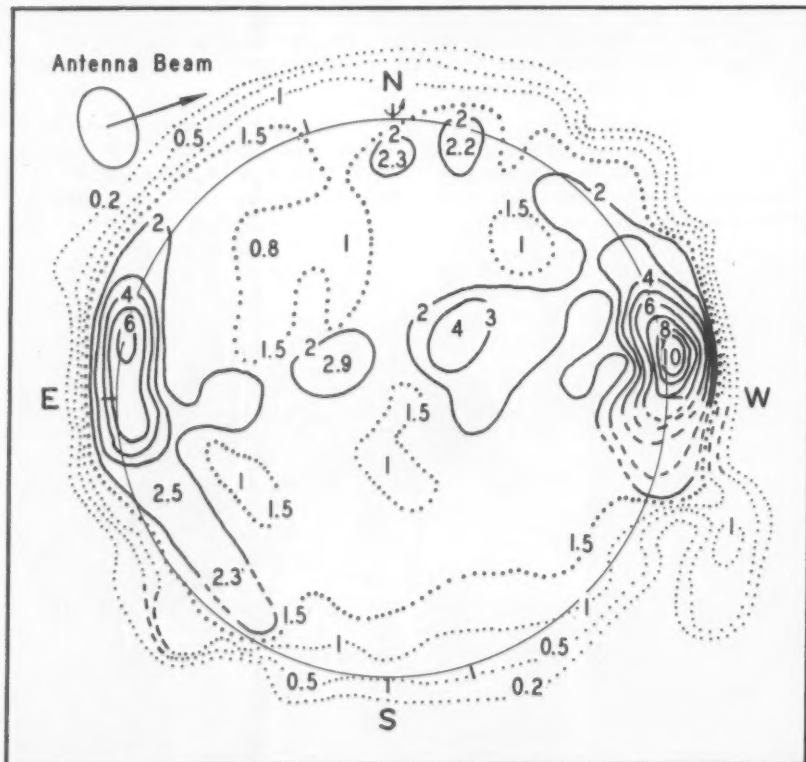
The remainder of this account, concerning Romania and Bulgaria, is based on a detailed letter from Prof. Calin Popovici, chief of the astrophysical department of Bucharest Observatory. Totality lasted 130 seconds there, but bad weather prevented carrying out an elaborate program of coronal photography and flash-spectrum study. However, Bucharest astronomers in a plane at 8,000 feet obtained five corona pictures through a 4.3-inch f/5 Zeiss objective. Exposures of 1/50 second were made on different kinds of plates, with standardization to permit photometric measurements.

The Romanian Sahia film studio also used aircraft for filming the eclipse in color with telephoto lenses, and secured remarkable color movies of the flash spectrum. Together with ground sequences showing eclipse expedition sites, the behavior of animals during the eclipse, and other features, this material has been combined into a color documentary film. It includes totality as seen from the ground at Craiova and Lehliu.

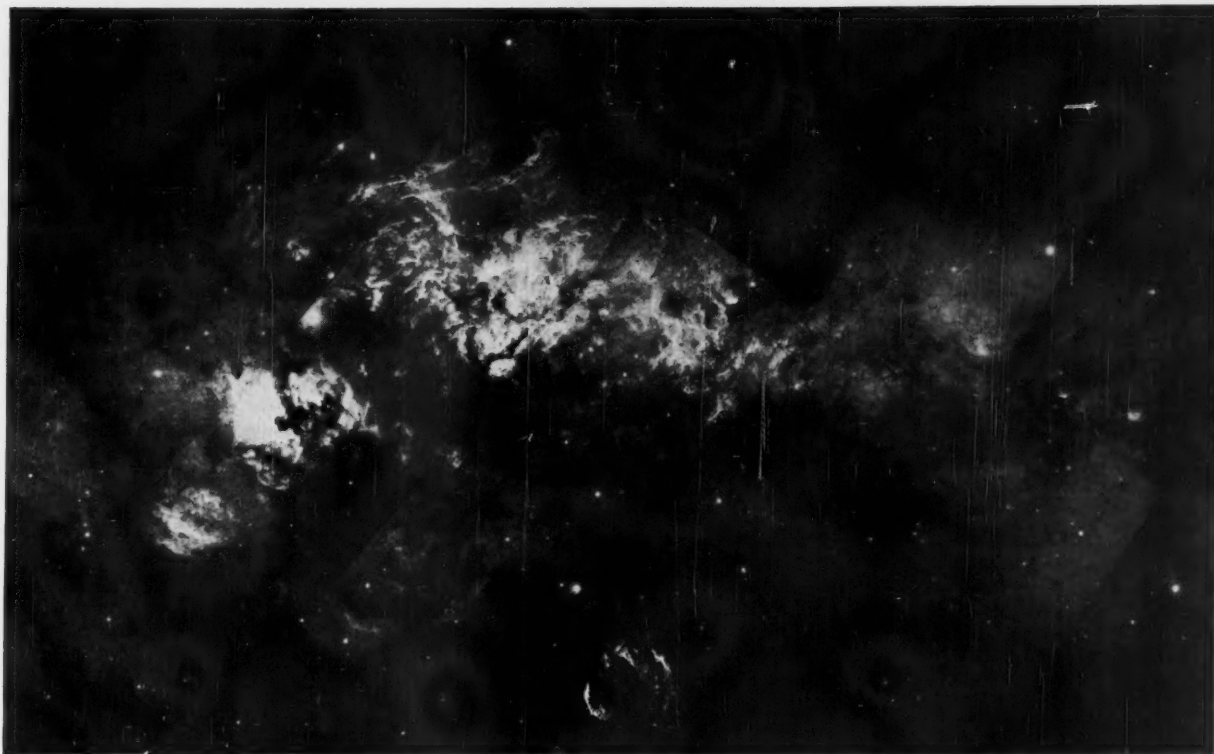
The Romanian observatories of Cluj and Iasi sent expeditions to Agigea, near Constanta on the Black Sea coast. Close by, at Basarabi, East German astronomers from Potsdam Observatory had set up their instruments, under the leadership of F. Jäger. At Constanta itself was a Hungarian team from Budapest Observatory, led by its director, L. Detre. But at these places, too, the weather was bad.

Prof. Popovici writes that just outside the path of totality observers saw shadow bands and the bright planets, even though the sun was not completely obscured. Amateurs sent in many eclipse pictures, but few of the corona.

The solar observatory at Debrecen, Hungary, sent two expeditions to northern Bulgaria to study the structure, brightness, and polarization of the corona. One of these teams enjoyed a completely cloudless sky at Silistra, but the other group at Ruse was hindered by passing clouds. Also at Ruse were Polish astronomers under E. Rybka, Krakow Observatory. They took motion pictures during the contacts, especially third, for geodetic purposes.



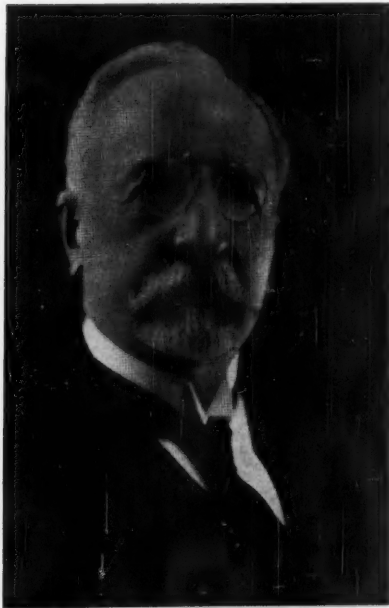
One of the provisional maps of the sun's radio emission at 9.1 centimeters, drawn by radio astronomers at Stanford University for 19^h to 20^h Universal time on eclipse day. The contour unit is 16,000° Kelvin, with dotted lines to indicate the weaker intensities. The Stanford microwave spectroheliograph had a beam-width of 3.1 minutes of arc in an east-west direction and five minutes north-south. Scanning of the sun was along approximately 15 parallel lines from west to east. N and S mark the sun's rotational axis.



Striking evidence for gas clouds lying among the stars is furnished by the Milky Way in Cygnus and neighboring constellations, as photographed in red light by the 48-inch Schmidt camera at Palomar Observatory. In this mosaic, the clouds are visible by their radiation in hydrogen light. Other constituents of the interstellar gas, such as calcium and sodium, are recognizable by the very narrow absorption lines they introduce in the spectra of background stars. Copyright National Geographic Society-Palomar Observatory Sky Survey.

Interstellar Gas Clouds

OTTO STRUVE, *National Radio Astronomy Observatory**



WHO was the first astronomer to realize that the "stationary" lines in the spectra of many distant stars originate from the absorption of light by interstellar gas clouds?

It is regrettable that recent astronomical literature has perpetuated a historical error in this connection. The background of the case is properly described by B. J. Bok and P. F. Bok in the 1957 edition of their book, *The Milky Way*:

"The discovery of the first [interstellar] absorption line goes back to 1904, when the German astronomer Hartmann showed that the absorption K line of ionized calcium in the spectrum of the star Delta Orionis behaved in a very peculiar fashion. Delta Orionis is a blue star with

The German astrophysicist Johannes Hartmann (1865-1936) discovered in 1904 an interstellar absorption line in the spectrum of Delta Orionis, and correctly explained it as due to a cloud of gas between us and that star. From the "Quarterly Notices" of the Astronomische Gesellschaft.

a B0 spectrum and was recognized to be a spectroscopic binary. Hartmann found, however, that the wave length of the K line did not vary at all in the course of the binary period. The hydrogen and helium lines in Delta Orionis were broad and fuzzy and varied, but its K line was sharp and distinct. Hartmann referred to the line as the 'stationary' calcium line."

But then the Boks go on to say, "The interstellar origin of [such] absorption lines was first suggested by V. M. Slipher in 1909 . . ."

It is sometimes difficult to establish the true history of a scientific event, even only half a century old, but in this case the evidence is clear. Johannes Hartmann's article, "Investigations on the Spectrum and Orbit of Delta Orionis," was published simultaneously in Germany and America. The latter version, in Vol. 19 of the *Astrophysical Journal* (1904), states:

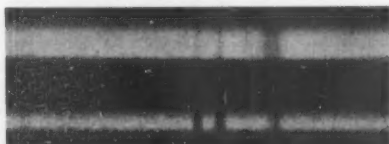
"We are thus led to the assumption that at some point in space in the line of sight between the Sun and δ Orionis there is a cloud which produces that absorption, and which recedes with a velocity of 16 km, in case we admit the further assumption, very probable from the nature of the observed line, that the cloud consists of calcium vapor."

Hartmann's revolutionary hypothesis

*Operated by the Associated Universities, Inc., under contract with the National Science Foundation.

was not immediately accepted, although supported by Slipher in 1909. Its revival was mainly due to A. S. Eddington's advocacy in 1926, when the theoretical interpretation of interstellar absorption lines was placed on a solid foundation, which has received further improvements since then.

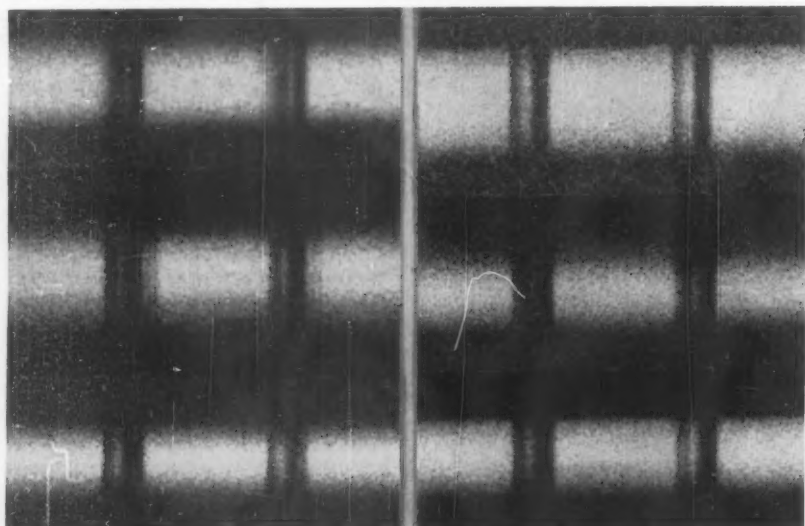
Observational confirmation of Hartmann's idea came more slowly, as spectrographic material gradually accumulated.



The spectra of a nearby star (top) and a distant star show how the two sharp lines of interstellar sodium are stronger at greater distances. Mount Wilson and Palomar Observatories photo.

In 1924, the Canadian astronomer J. S. Plaskett suggested, on the basis of his observations, that the stationary lines are produced by absorption in a "widely distributed tenuous cloud of matter" enveloping the stars, and that its calcium atoms would be ionized in the vicinity of the hotter stars.

In 1925, I attributed the phenomenon of stationary calcium lines to vast clouds which "show a strong concentration toward the plane of the Milky Way, where they seem to cover practically every square degree in greater or smaller density. The clouds form separate masses which show small but definite systematic motions with respect to the stellar system as a whole. In high galactic latitudes the clouds are scarcer, and it is probable that at least in some directions the line of sight does not encounter any such clouds."

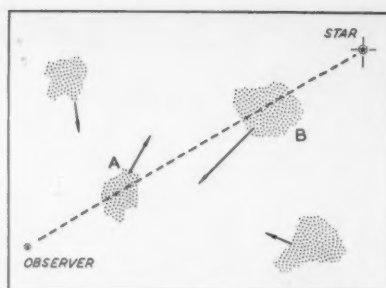


Guido Münch took these spectra of six stars in the Perseus spiral arm of our galaxy. Each section shows the interstellar D1 and D2 lines of sodium. Note how in every case the complex structure of one sodium line matches its neighbor. The 100-inch Mount Wilson reflector was used for these spectrograms, enlarged from an original scale of 6.8 angstroms per millimeter. The spectrograms with this article are from the "Astrophysical Journal."

Two years afterward, I was able to show that the strength of the interstellar calcium lines increases with the stars' distances, up to at least 500 or 600 parsecs from the sun, in low galactic latitudes. Later studies by T. Dunham, Jr., myself, and others, proved that the diffuse interstellar gas is mostly hydrogen. While it does not produce observable Balmer absorption lines, it furnishes enough free electrons to maintain the ionization of the calcium gas at the observed level.

But in this later work, mostly around 1930 to 1940, astronomers largely lost sight of the nonuniformity in the distribution of the interstellar gas clouds. According to the Boks: "Until 1936, astrophysicists supposed that the interstellar gas was distributed smoothly through a thin layer near the central plane of the Milky Way." But in that year, C. S. Beals reported that interstellar lines were sometimes multiple, indicating that more than one absorbing cloud lay between us and the star. Subsequently at Mount Wilson Observatory, W. S. Adams found that about half of the 300 stars he observed had double or triple interstellar K lines, and in several stars this feature had four components. These observations were used in F. L. Whipple's detailed analysis of the regional character of the clouds, along the lines of my investigation of 1925.

The multiple structure of an interstellar absorption line is caused by differences in the radial velocities of separate clouds along the line of sight to the star. The individual clouds vary greatly in size, but the average diameter is in the neighborhood of 20 or 30 light-years. The number of clouds penetrated by the line of sight is about nine or 10 for each 1,000 parsecs from us.



When two interstellar clouds moving with different velocities lie between us and a star, as in this diagram, interstellar lines superimposed on the stellar spectrum are doubled. The component due to receding cloud A is shifted in the red direction, that due to approaching cloud B toward the shorter wave lengths of the spectrum, because of the Doppler effect.

The most important recent studies of interstellar lines are those published in 1957 by Guido Münch, and by Münch and Harold Zirin in the *Astrophysical Journal* for January, 1961. These papers follow up Adams' 1949 finding that "the radial velocity from individual components in 7 stars exceeds 50 km/sec and reaches nearly 100 km/sec in one case, but the strongest component nearly always gives a low velocity. Double stars and stars close together in position usually show the same structure for the H and K lines, and nearly the same radial velocities." However, there are indications that high-velocity clouds are smaller than low-velocity ones, because neighboring stars occasionally have dissimilar highly displaced components, while the strong but slightly displaced components are essentially the same.

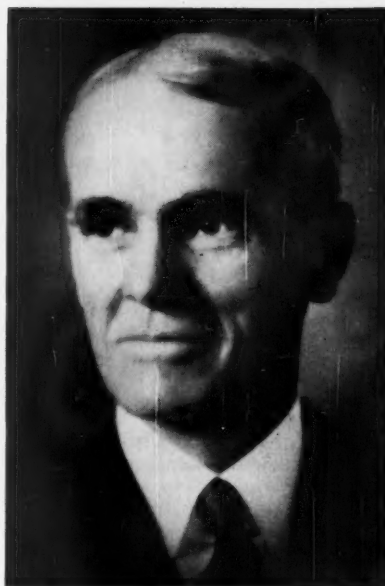
In his 1957 paper, Münch listed the radial velocities and intensities of the interstellar calcium and sodium lines in 112 very distant stars, located near the galactic plane and with galactic longitudes between 55° and 160° (in Lacerta, Cassiopeia, Perseus, Auriga, and Orion). The remotest of these stars, some 3,000 parsecs away, usually showed two strong absorption components. One was produced by nearby clouds located in our spiral arm of the Milky Way (the Orion arm), the other by clouds in the next outer arm, the Perseus one. Occasionally, in addition to these strong components, there were fainter, highly displaced lines, evidently due to small high-velocity clouds.

The 1961 paper by Münch and Zirin contains observations of interstellar lines in the spectra of two dozen distant O- and B-type stars at high galactic latitudes, ranging from 240 to 2,700 parsecs above and below the galactic plane. The spectra of all these stars show interstellar components; some gas clouds probably occur 1,000 parsecs from the plane, and have velocities of the order of 50 kilometers per second toward or away from the plane.

This discovery of fast-moving gas clouds at high galactic latitudes is a major advance in astrophysics. Münch and Zirin have attempted to explain the origin of these features and their physical properties. First of all, they point out "the rather different appearance of the complex interstellar lines in high galactic latitude stars . . . from that observed in stars near the galactic plane. . . . In Milky Way stars at distances not greater than, say, 1 kiloparsec from the sun, invariably one strong component, with a small Doppler shift, is observed, around which lines with larger shifts may appear with considerably smaller strength. In high galactic latitude stars with complex lines, in contrast, we observe the component with smallest velocity . . . [to have a] strength comparable to the others. The difference is, of course, due to the fact that the strong lines in the Milky Way either arise from the partial superposition of a number of weaker lines or are formed in extensive gas masses with considerable internal mass motions."

Nowadays there is a great deal of evidence that dust clouds exist at high galactic latitudes, in the form of reflection nebulosities and dark nebulae. Mrs. B. T. Lynds has called my attention to several objects of this type in the Palomar Sky Survey prints. Thus, on Plate 1317 (right ascension 8^h , declination $+46^\circ$) there is a conspicuous reflection nebula, apparently associated with the stars HD 65914 (magnitude 7.6, spectrum F5) and HD 65715 (8.2, K0), in galactic latitude $+31^\circ$. Its distance above the galactic plane is not known, but may be less than 100 parsecs. Much more distant dust clouds can probably also be detected, and, like dust clouds near the central plane of the Milky Way, they presumably contain gas.

From the radial velocities of the clouds, and their present distances above and below the galactic plane, Münch and Zirin estimate lifetimes of the order of 40



Much of our present knowledge of interstellar lines has come from extensive spectroscopic observations by Walter S. Adams (1876-1956) with the 60- and 100-inch reflectors of Mount Wilson Observatory. He was director there from 1923 to 1946.

million years. High-velocity clouds in low latitudes have much shorter lives, perhaps only a tenth as long. They are presumably dispersed by collisions with other clouds and by the drag exerted upon them by the more tenuous gaseous substratum of the Milky Way. But such a cloud, propelled away from the central plane, will encounter very few others after it has attained a distance of a few hundred parsecs above or below the plane. At distances of several thousand parsecs, the probability of collision with another cloud would be very small.

On the other hand, a cloud moving into empty space should be expected to expand fairly rapidly, and would lose its

identity in less than 40 million years. Münch and Zirin therefore suggest that this expansion is restrained by a highly rarefied but very hot galactic corona, whose pressure is sufficient to overcome the tendency of the relatively dense and cool clouds to grow. Such a galactic corona had previously been suggested by Lyman Spitzer, Jr., from other considerations.

With an electron temperature of 1,000,000° Kelvin and a density of only 0.0005 hydrogen atom per cubic centimeter, the corona would be too tenuous to be observed in emission with present astronomical techniques, and too highly ionized to cause absorption in the currently accessible region of the spectrum. But it could prevent a high-velocity cloud from expanding rapidly.

HARVARD SUMMER INSTRUCTION IN OBSERVATIONAL ASTRONOMY

In a program supported by the National Science Foundation, astronomy students from several American universities will participate in three months of observing at the Agassiz Station of Harvard Observatory, beginning June 15th. Dr. Morton S. Roberts is in charge of the instruction and research, and will be assisted by other Harvard faculty members. The students will work with the 61-inch reflector, using modern photoelectric and spectrographic equipment, the maser-equipped 60-foot radio telescope, and other instruments, all located at Harvard, Massachusetts.

COESITE AND METEOR CRATERS

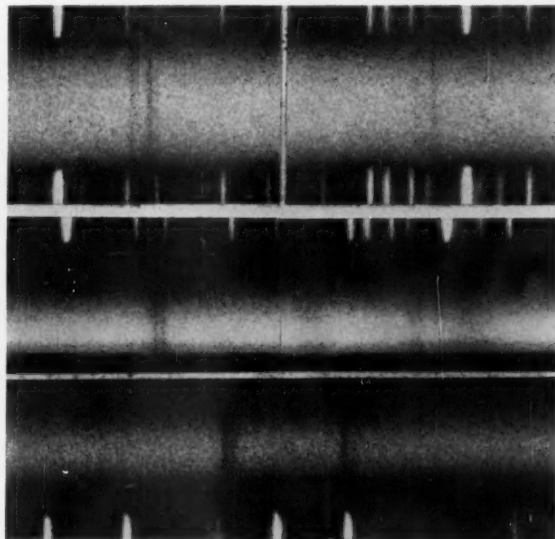
Coesite is a form of silica (SiO_2) produced under high pressure in laboratory experiments. It was not known to exist naturally until last year, when it was identified in rocks from three meteoritic craters. These are Meteor Crater in Arizona; the Rieskessel, Bavaria, Germany; and Wabar Crater near Al Hadida, in east-central Arabia.

The Arabian crater is about 300 feet in diameter and about 40 deep, the result of the impact of an iron meteorite in sandstone. Identification of natural coesite from this crater was reported by E. C. T. Chao, J. J. Fahey, and Janet Littler, of the U. S. Geological Survey, in *Science*, March 24, 1961. The mineral was found in both the fractured sandstone and the black glass characteristic of this site.

The significance of the find is that pressures of at least 20 kilobars (150 tons per square inch) are needed for coesite to form. Such conditions are not likely to be produced at the earth's surface except by impact. Dr. Chao and his colleagues therefore suggest that the occurrence of coesite is a good indicator of impact craters.

This work is part of a program of crater studies sponsored by the National Aeronautics and Space Administration.

Here are complex interstellar lines of two stars far from the galactic plane. Top: K line (left) and H line of calcium, in the star HD 93521. Middle: The same absorptions in HD 119608. Bottom: The D1 and D2 lines of interstellar sodium for the latter star. These are Mount Wilson and Palomar pictures taken by Guido Münch.



GETTING ACQUAINTED WITH ASTRONOMY

THE PLANETS — JUPITER

ELEVEN times larger in diameter than the earth and accompanied by a retinue of a dozen known satellites, Jupiter revolves around the sun in an 11.9-year period at an average distance of 484 million miles. This giant world is more massive than all the other planets combined. Its strong gravitational attraction modifies the motions of the other planets from Mercury out to Pluto, and strongly changes the orbits of neighboring Saturn and the asteroids. Next to the sun, it is the dominating member of the solar system.

Jupiter differs strikingly in construction from the earth and other inner planets, which are small, dense, slowly rotating bodies with little or no atmosphere. Long ago, Jupiter's average density was found to be only 1.3 times that of water, and it could be inferred from the planet's rapid rotation and oblateness that its mass was strongly concentrated toward the center. An important advance was R. Wildt's spectroscopic discovery in 1931 of ammonia (NH_3) and methane (CH_4) in Jupiter's deep cloud-laden atmosphere, which led to the realization that the planet is composed mainly of hydrogen and hydrogen compounds.

According to the latest theoretical study by W. de Marcus (1958), Jupiter is at least 78 per cent hydrogen by weight.

Two photographs of Jupiter made in rapid succession at about 5:01 Universal time on August 28, 1950, by Edwin E. Hare with a 12-inch reflector. The shadow of satellite Io is visible near the center of the planet's disk, on the south equatorial belt.



The body of the planet consists of gas solidified under pressure, enveloped by an atmosphere 470 miles in depth. We do not see the true surface at all, only the top of the cloud layer.

Early in 1955, B. F. Burke and K. L. Franklin discovered that Jupiter emits intense radio noise. Observations at wave lengths of several meters show "storms" lasting from five minutes to an hour, made up of repeated bursts of static originating from the planet. Radio astronomers at several observatories are studying this strange behavior, which, when fully understood, may help explain other Jovian puzzles.

Even to the naked-eye watcher, Jupiter is an object of special interest. It is easy to keep track of, as it appears to move eastward one constellation of the zodiac

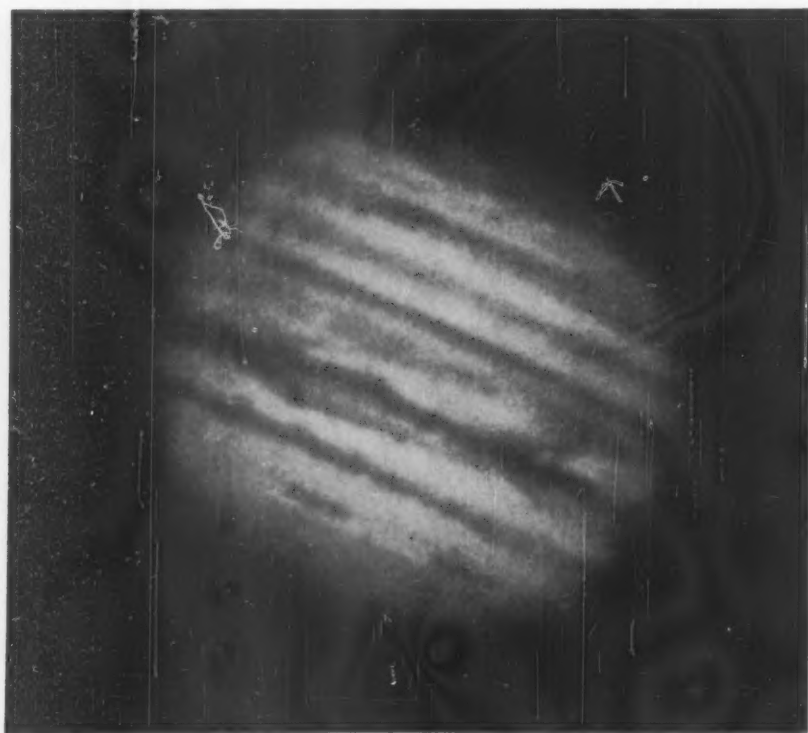
each year. Generally, this brilliant golden-yellow planet outshines all others except Venus. Only for two or three months each year is it too near the sun in the sky to be well seen. At an average opposition to the sun, it shines at magnitude -2.3 and has a distance of about 390 million miles from the earth.

Richly toned, constantly varying dark and bright markings in the cloud layer make Jupiter one of the most rewarding objects for observation in amateur telescopes. At opposition on July 25th this year, the planet will present a flattened disk fully 48 seconds of arc in equatorial diameter and 45 in polar, recognizable even in binoculars together with the four brightest satellites. A 3-inch refractor affords pleasing views, but telescopes larger than six inches are recommended for systematic observing.

Most conspicuous of disk features are the dark belts and bright zones parallel to the planet's equator. The accompanying chart indicates the standard nomenclature for them, as used by American and British observers. The appearance of these markings varies considerably; a belt may be sometimes wide and dark, at other times thin and faint, or even invisible. Occasionally a belt, especially the South Equatorial Belt (SEB), may be divided into two components by a bright rift or zone.

A moderate-size telescope reveals much structural detail in the belts and zones. Dark projections and bright indentations (bays) are frequently seen along the edges of the belts. Thin dusky streaks (festoons) sometimes develop in the zones, especially the Equatorial Zone (EZ). A festoon may appear as a loop terminating at two dark spots in the same belt, or it may extend across the zone, linking dark spots in adjacent belts. Many small areas, bright and dark, may usually be seen on the belts and zones, and are referred to simply as spots. These lesser markings are transient features, some changing from night to night and vanishing after a few days or weeks, others persisting for many months.

Amid the turmoil in Jupiter's atmosphere, the great red spot has maintained



For planetary photography, the long focus and good definition of large refracting telescopes are advantageous. This is a 21x enlargement of a negative taken with Lick Observatory's 36-inch refractor by H. M. Jeffers.

its identity for over 80 years — perhaps much longer. This famous feature has displayed many aspects since it first became prominent in 1878. In recent years the red spot has sometimes been visible as a dusky orange-ochre ellipse about 22,000 miles long and 8,000 miles wide. At other times, the red spot itself has been quite invisible, but its position has remained marked by the red spot hollow. This is a white notch or bay in the south edge of the South Equatorial Belt.

Jupiter turns on its axis more rapidly than any other planet, completing one rotation in slightly under 10 hours. But observations of well-defined spots have shown that the rotation period is not the same in different latitudes. It is generally shortest in the equatorial regions and longer in higher latitudes, but the variation with latitude is irregular, and there are marked differences between the northern and southern hemispheres.

Even in the same latitude, different spots commonly yield different periods, and the rotation rates vary slightly from year to year. Evidently, the detail we observe on Jupiter belongs not to the solid surface but to the extensive cloudy atmosphere, which contains many sharply bounded currents moving parallel to the planet's equator.

On the average, the great equatorial current has a period of $9^h 50^m 30^s$, which is about five minutes shorter than for the rest of the planet, where periods range from $9^h 55^m$ to $9^h 56^m$. Because of this, we use two systems of longitude. Since there are no permanent fixed markings visible on Jupiter from which longitudes can be measured, the systems are based on two arbitrary meridians adopted by A. Marth in 1896.

System I longitude, measured from a meridian rotating uniformly in $9^h 50^m 30^s.003$, is used for the Equatorial Zone (EZ), the south edge of the North Equatorial Belt (NEBs), and the north edge of the South Equatorial Belt (SEBs). System II longitude, rotating in $9^h 55^m$

$40^m.632$, is used for the remainder of the planet.

At the foot of this page appears Elmer J. Reese's tabulation of the Jovian zones and belts, which may be compared with his accompanying drawing. It was made on July 11, 1949, at 5:30 Universal time, when the central meridian's longitude was 323° in System I and 208° in System II. Sky transparency was 4 on a scale of 5, and seeing was 4 on a scale of 10.

The central meridian of Jupiter is the imaginary line extending from pole to pole, bisecting the fully illuminated disk of the planet. When the planet is not near opposition, there is a slight phase effect, and the apparent central meridian requires a small correction. The *American Ephemeris* lists (on pages 332-333 of the 1961 volume) the longitude of the

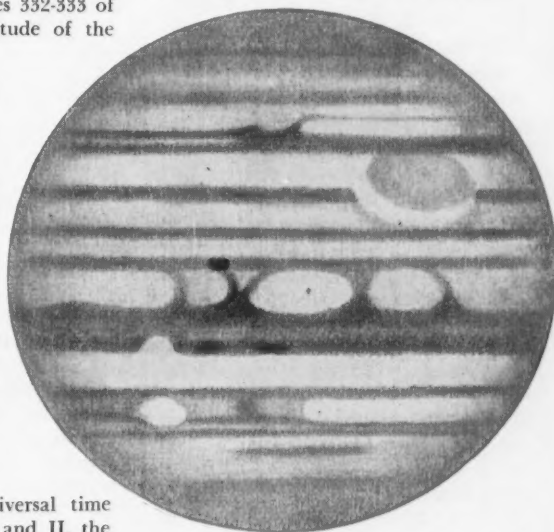
On July 11, 1949, Elmer J. Reese timed central meridian transits of 16 Jovian features. The first transit, of the center of a small white oval (lower left) in the north temperate zone, was at 4:40 Universal time. The small dusky spot in that same zone followed 36 minutes later. Above the first spot is a white bay cutting the north edge of the north equatorial belt; this transited at 4:44. The very dark spot in the equatorial belt crossed at 5:09, while the red spot's center (upper right) reached the meridian at 6:21.

central meridian for 0^h Universal time every day in both Systems I and II, the phase correction being already included. There are also supplementary tables giving the change in longitude in intervals of mean time. Hence it is easy to find the central-meridian longitude corresponding to the moment of observation.

Central-meridian transit observations have supplied most of our present knowledge of the motions of currents in Jupi-

ter's atmosphere. Few observing programs are at once so easy and so useful. The observer merely records the time, to the nearest minute, when each Jovian spot appears to be on the central meridian. As the planet rotates on its axis, the spots move from right to left across the disk, when viewed in an inverting telescope. A spot near the central meridian shifts noticeably in five minutes, and the probable error of a transit observation is usually not greater than two or three minutes. Each observation should include the date, time of transit, a brief description of the object, and its location with regard to the belts and zones.

The longitude of each spot is simply that of the central meridian, System I



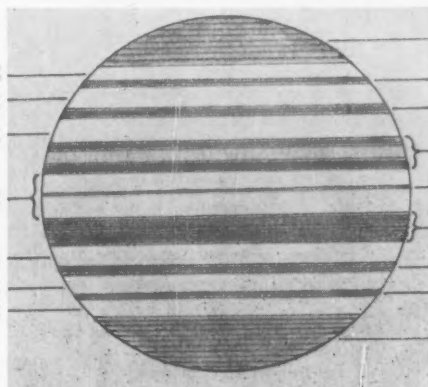
or II as the case may be, for the observed time of transit. The symbols λ_1 and λ_2 are used to indicate longitudes in System I and II, respectively. If the same spot has been repeatedly observed for some weeks or months, its rotation period can be determined from a graph in which the observed longitude is plotted against date. (A convenient scale is 1/10 inch to four

BELTS AND ZONES ON THE PLANET JUPITER

THE BRIGHT ZONES

Names and Abbreviations

S. S. Temperate Zone	SSTeZ
S. Temperate Zone	STeZ
S. Tropical Zone	STrZ
Equatorial Zone	EZ
N. Tropical Zone	NTrZ
N. Temperate Zone	NTeZ
N. N. Temperate Zone	NNTeZ



THE DARK BELTS

Names and Abbreviations

S. Polar Region	SPR
S. S. Temperate Belt	SSTeB
S. Temperate Belt	STeB
S. Equatorial Belt	SEB
Equatorial Band	EB
N. Equatorial Belt	NEB
N. Temperate Belt	NTeB
N. N. Temperate Belt	NNTeB
N. Polar Region	NPR



Two aspects of Jupiter's red spot, as depicted by Elmer J. Reese. At the left the spot itself is seen, at the right only the hollow. From top to bottom, horizontal dark regions are the south temperate belt, the southern part of the south equatorial belt, and its northern part.

degrees of longitude and 1/10 inch to two days.)

From such a graph, the spot's rate of drift in longitude can be established. Then the rotation period can be computed by one of the following formulae:

Markings in System I:

$$\text{Period} = 9^h 50^m 30^s.003 + 1^s.345D_1$$

Markings in System II:

$$\text{Period} = 9^h 55^m 40^s.632 + 1^s.369D_2$$

Here D_1 is the number of degrees a marking drifts in longitude in 30 days in System I; D_2 refers to System II. D_1 and D_2 are positive if the marking's longitude increases with time, negative if it decreases.

During a night's work, the observer will sometimes clock several dozen transits of the centers, preceding ends, and following ends of different markings. Record keeping will be greatly aided by the following set of abbreviations, which are in general use:

- D — dark marking
- W — bright marking
- c — center
- p — preceding, preceding end
- f — following, following end
- N — north
- S — south
- v — very
- l — large
- sm — small
- proj — projection
- cond — condensation
- elong — elongated
- conspic — conspicuous
- indef — indefinite
- sect — section
- RS — red spot
- RSH — red spot hollow.

Thus, the following end of a darker section of the North Temperate Belt can be written: Df (sect) NTeB.

Drawings of Jupiter, if made with care, form a valuable record of the changing appearance of the planet. A template for the elliptical disk (polar flattening is approximately 1/15) can be cut from a thin sheet of cardboard or metal. A convenient scale is $2\frac{1}{2}$ inches to the equatorial diameter, corresponding to 2.33 inches for the polar one. When making a full-disk drawing of Jupiter, the observer must work rapidly, for otherwise his picture will be distorted by the planet's rapid rotation.

First, lightly sketch in the more promi-

nent belts, giving close attention to their widths and latitudinal positions. (There is less need to hurry here since rotation has little effect on belt latitudes.) Next, noting the time to the nearest minute, quickly sketch in a half-dozen or so prominent spots on various portions of the disk, taking only a minute or so. With this done, the lesser details can be drawn at greater leisure in their proper places relative to the prominent markings already inserted. Each completed drawing should be labeled with the date, time, and other circumstances, for it to have later usefulness.

Good photographs of Jupiter can be taken with larger amateur telescopes, and provide an accurate and permanent record of the positions, widths, and intensities of the various belts and zones. In particular, the latitudes of the belts can be measured from a photograph, using a finely divided scale. A full explanation of latitude determination is given in Chapter 6 of B. M. Peck's *The Planet Jupiter* (Macmillan, 1958). This book is strongly recommended as a mine of useful information for systematic observers of the giant planet.

Both the Association of Lunar and Planetary Observers and British Astronomical Association have active Jupiter sections engaged in co-operative observing. Any amateur planning serious observations should contact one or both organizations. The ALPO Jupiter recorder is Philip R. Glaser, 400 E. Park Ave., Menomonee Falls, Wis.; the director of the BAA's Jupiter section is A. F. O'D. Alexander, 1 Athelstan Rd., Dorchester, Dorset, England.

ED. NOTE: This article is largely based upon material originally written by Elmer J. Reese for the Astronomical League observing manual.

Sky and Telescope Binders

Dark blue fabrikoid binders priced at \$3.50 each, postpaid in the United States; \$4.00 in Canada. Two sizes: Binder C is for volumes up to XVIII; Binder D is for volume XIX and after. If it is desired to put two of the current volumes (a total of 12 issues) into a single binder, order Binder C instead of D.

Your name can be gold-stamped for 75¢ extra, each volume number for 50¢; name and volume number, \$1.20; name and two volume numbers, \$1.70. Print all desired lettering clearly.

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Sky Publishing Corporation

Harvard Observatory, Cambridge 38, Mass.

QUESTIONS... FROM THE S+T MAILBAG

Q. How many comets have been observed?

A. Prior to the invention of the telescope, about 880 comets were recorded; from 1600 to 1950, 741 were found. These figures were compiled by F. Baldet.

Q. What is the greatest distance from the earth at which a comet has been observed?

A. Comet Stearns 1927 IV was last photographed 11.5 astronomical units (1.1 billion miles) from Earth, more than four years after it had passed the perihelion point of its orbit.

Q. How can I change the power of my binoculars?

A. Replace the eyepieces with ones of longer or shorter focal length. However, performance will probably not be as good, since binocular optics are usually designed as a unit.

Q. Do the Trojan asteroids stay close to the orbital points 60 degrees ahead of and behind Jupiter?

A. No. They oscillate considerable distances away from the 60-degree points, in periods of about 160 years. In *Leaflet No. 381* of the Astronomical Society of the Pacific, March, 1961, Seth B. Nicholson says, "The record is held by Diomedes which may go as far as 40° beyond the 60° point on the side away from Jupiter and 24° from it on the side toward Jupiter."

Q. What is meant by the anomalistic period of an artificial satellite?

A. It is the time interval between successive passages of the satellite through its perigee — the point in its orbit closest to the center of the earth.

Q. Why do the rings of Saturn appear tilted differently from year to year?

A. The rings always remain in the planet's equatorial plane, which is tipped about 27 degrees to the orbital plane. Thus, as Saturn moves around the sun, at times we see the rings edgewise, at other times opened up. The next edge-on presentation will be in 1966.

Q. How much does the brightness of Uranus vary?

A. At average opposition, the visual magnitude of Uranus is 5.7, but at a perihelion opposition it is 5.5, at an aphelion one 5.9. In any one year, the planet fades by only 0.2 magnitude as it passes from opposition to conjunction with the sun.

Q. How many different new books on astronomy are published each year?

A. Between 100 and 150 in all languages, if serial publications are not included. Only a rough estimate is possible, because of the difficulty in drawing a dividing line between astronomy and other subjects.

W. E. S.

NEWS NOTES

COOLING PHOTOGRAPHIC EMULSIONS

Astronomers seeking to photograph very faint stars or nebulae in long exposures are greatly troubled by a well-known property of photographic emulsions — reciprocity failure. The image density does not increase at the same rate as exposure time.

However, by lowering the temperature of the film the effect can be eliminated. Extreme cold also reduces sensitivity, but there is an optimum temperature for each combination of emulsion, light level, and exposure time.

This conclusion was reached by Arthur A. Hoag from his experiments at the Flagstaff, Arizona, station of the U. S. Naval Observatory. Several different emulsions have shown appreciable gains in speed at -35° centigrade as compared with $+5^{\circ}$. For example, cooling reduces by a factor of three or more the exposure time needed for Kodak 33 plates to record 20th-magnitude stars with the 40-inch reflector.

Dr. Hoag has obtained a spectacular gain in speed and correction of color balance for long exposures with Kodak High Speed Ektachrome. For this he used a special evacuated camera with an anti-reflection coated window, the emulsion being chilled by conduction. Slightly better results are reported at dry-ice temperature (-78° C.) than at -38° . His work is summarized in the *Publications*, Astronomical Society of the Pacific.

ELLIPTICITY OF THE EARTH'S EQUATOR

For many years, geodesists have suspected that the equatorial cross section of the earth is not exactly circular. On the assumption that this cross section is an ellipse, they have attempted to deduce its shape from a comparison of gravity measurements made in various parts of the world. The results have been discordant, although suggesting the existence of such a bulge.

Imre G. Izak of the Smithsonian Astrophysical Observatory has now shown that the equatorial diameter passing through a point in the Atlantic just off Brazil is about 1,300 feet longer than the equatorial diameter at right angles to it. This finding was made from a detailed analysis of photographic observations of two artificial satellites, Vanguards II and III.

He first deduced that for an elliptical equator certain orbital elements of a satellite should show small variations in an approximately half-day cycle. The largest such perturbation occurs in the location of the ascending node; smaller effects take place in the inclination, mean anomaly, and location of perigee. For each case, the amplitude of the perturbation is proportional to the ellipticity of the equator.

Mr. Izak proceeded to evaluate these amplitudes from satellite observations made with Baker-Nunn cameras at Smithsonian tracking stations. These cameras furnish satellite positions accurate to two seconds of arc for times known to 1/1,000 second. For 1959₁ he used 187 observations made in April, 1960, and for 1959₂, 217 in May, 1960. Both objects have large perigee heights, reducing the complicating effects of atmospheric drag. The very extensive calculations were made with an IBM 704 computer.

Parallel computations for the two satellites gave quite accordant results. Together, they indicate that the ellipticity of the terrestrial equator is 3.21×10^{-5} , a value uncertain by 10 per cent of its amount; the geographical longitude of the longest diameter is $33^{\circ}.15$ west, within about half a degree. Mr. Izak points out that his determination will be improved when more accurate latitudes and longitudes of the Baker-Nunn camera stations become known.

HELIUM FLASH IN GIANT STARS

After a star of Population II has evolved away from the main sequence of the Hertzsprung-Russell diagram and become a red giant star, a remarkable "thermal runaway" occurs deep in its interior. This had been predicted by E. Mestel, and is now confirmed in step-by-step calculations of helium burning in giant stars by R. Härm and M. Schwarzschild at Princeton University Observatory.

They traced the development of a model star, with a mass 1.3 times the sun's, through the phase of its evolution when the thermonuclear consumption of helium begins. Forty per cent of the mass is in a central core of helium, the atoms being in a degenerate state — stripped of their outer electrons and packed together to a density of a million grams per cubic centimeter. The burning of hydrogen continues in a shell of non-degenerate matter just outside the helium core.

The helium burning sets in when the temperature in the contracting core reaches about 80 million degrees Kelvin. The energy released can only raise the temperature further, as the high pressure on the degenerate matter prevents its expansion. The helium burning thus becomes more and more rapid, with the temperature continuing to rise to a maximum of about 350 million degrees! At that time, the core is liberating as much energy as 10^{11} suns, but practically none of this escapes, because of the high opacity of the hydrogen shell.

At such a high temperature, the core is finally forced to expand, and only when it becomes nondegenerate does the ther-

IN THE CURRENT JOURNALS

THE TROJAN ASTEROIDS, by Seth B. Nicholson, *Leaflet* No. 381, Astronomical Society of the Pacific, March, 1961. "Among the 1627 asteroids with known orbits, fourteen have periods approximately equal to that of Jupiter. Because these exceptional asteroids have been named after heroes in the Trojan War, as told by Homer in the *Iliad*, they have become known as the 'Trojan Asteroids.'"

SIR WILLIAM HERSCHEL AND HIS PLACE IN THE HISTORY OF SCIENCE, by Walter Balderston, *Journal* of the Royal Astronomical Society of Canada, February, 1961. "Astronomers, especially amateur astronomers for whom he could appropriately be a patron saint since he began as an amateur, may justly hold William Herschel to be the founder of the modern period of their science. But Sir William's place in history is more important and significant than even this suggests."

THINGS THE ASTRONOMER DOES NOT DO, by Robert S. Richardson, *Griffith Observer*, March, 1961. "A woman was calling to tell us about a brilliant meteor she had seen the night before. Had we seen it at the Griffith Observatory? We had to confess that we had not. The woman couldn't believe it. It was so bright! How could we have missed it? We tried to explain the situation to her, but it was no use. Don't astronomers spend all night looking at the sky? she demanded. Then why can't they see what's going on up there?"

mal runaway terminate, with subsequent helium burning causing rapid expansion and cooling. On a cosmic time scale, the duration of the helium flash has been very brief, lasting about 3,000 years.

During the peak of the helium flash, the star moves downward to the left along the giant branch of the H-R diagram, according to the Princeton astronomers, physical changes taking place with great rapidity. The normal time step in their calculations on an IBM 650 computer was 100,000 years, with shorter steps used when the evolution took place faster. However, at one stage of the helium flash the star's state had to be recalculated for two-second intervals. Dr. Schwarzschild pointed out that such a star would actually be evolving at a faster rate than even his high-speed computer could operate!

In this work certain assumptions had to be made that may require adjustment of the calculation if they later prove incorrect. Hydrostatic conditions were assumed to hold, with dynamical effects neglected. The validity of this simplification must be tested further.

Amateur Astronomers

THIS MONTH'S PROGRAMS

Cleveland, Ohio: Cleveland Astronomical Society, 8 p.m., Warner and Swasey Observatory. May 12, Dr. Thornton Page, Wesleyan University, "Beyond the Milky Way."

Glen Burnie, Md.: Chesapeake Astronomical Society, 8 p.m., Harundale Presbyterian Church. May 11, Milton Moore, "Astrophotography."

New Orleans, La.: Pontchartrain Astronomy Society, 8 p.m., Tulane University Observatory. May 5, Dr. J. A. Lyon, Tulane University, "Significance of Stellar Colors."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. May 17, Leslie R. Blasius, New York Telephone Co., "Man in Space."

Shreveport, La.: Shreveport Junior Astronomical Society, 7:30 p.m., Centenary College science hall. May 20, Wilson B. Schramm, Marshall Space Flight Center, "Future Deep Space Probes."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Department auditorium. May 6, Donald A. Rice, U.S. Coast and Geodetic Survey, "Astronomy and the Earth's Gravity Field."

AAVSO TO MEET

The American Association of Variable Star Observers begins celebration of its 50th year with a spring meeting at the National Research Council laboratories in Ottawa, Canada, May 26-27, at the invitation of the Ottawa Centre of the Royal Astronomical Society of Canada.

"Biosciences and Space Research" is the title of the Friday evening lecture by Dr. M. G. Whillans, Defence Research Board of Canada. In addition, there will be visits to the Springhill Meteor, Goth Hill Radio, and Dominion observatories.

Further information may be obtained from AAVSO headquarters, 4 Brattle St., Cambridge 38, Mass., or from the Ottawa Centre.

IAN HALLIDAY
Dominion Observatory
Ottawa, Canada

SOUTHEAST CONVENTION

Clarence Jones Observatory, Chattanooga, Tennessee, is the location of the 1961 convention of the Astronomical League's Southeast region. Sponsored by the Barnard Astronomical Society of Chattanooga, the meeting will be held May 5-7.

Conrad Swanson, of the George C. Marshall Space Flight Center in Huntsville, Alabama, is to lecture on "Aurora-Saturn: The 24-Hour Orbiting Telescope Project." Also, Dr. William Calder of Bradley Observatory will speak on the

importance of binary stars to astrophysical research.

Those desiring to present papers or exhibits should inform regional secretary Llewellyn Evans, 68 S. Crest Rd., Chattanooga 4, Tenn. Commercial displays will be welcome.

HENDRIK R. HUDSON
Bradley Observatory
Agnes Scott College
Decatur, Ga.

GREAT PLAINS CONVENTION

The Fisher Community Center at Marshalltown, Iowa, will be the site of the Great Plains Astronomical Society convention, June 9-11. The program begins Friday evening with a welcoming get-together, and the main sessions will be on Saturday afternoon and Sunday. "Group Projects" is the theme.

Further information may be obtained from LeRoy E. Doggett, 106 N. 3rd Ave., Marshalltown, Iowa.

BRISTOL, PENNSYLVANIA

The Polaris Astronomical Society of Bristol celebrates its sixth anniversary during May. Started with five members, the club now has 14. Meetings are on the second Friday of each month. Karl F. Koehler, director of the group, designed and constructed its DelVal Observatory on his property.

Anyone over 18 years old living in the vicinity is invited to join the society, 3524 Carnarvon Ave., Bristol, Pa.

LONG ISLAND, NEW YORK

Expanding its membership over a larger geographical area, the 12-member Bay Shore-Brightwaters Junior Astronomical Society has changed its name to Long Island Junior Astronomical Society. Activities include lectures by Percy M. Proctor of Babylon, and star parties. Richard B. Spivak, 517 Manatuck Blvd., Brightwaters, N. Y., club president, wishes to correspond with other societies.

KAMPAR, MALAYA

A small observatory, the first one in this country, has been built at the Pei Yuan high school, latitude 4° 19' north, longitude 101° 10' east. We have a 6-inch reflector, a 4-inch refractor, and five 44-mm. refractors for student instruction.

The study of natural science, particularly astronomy, is not very common in Malaya, but we hope to increase the interest as our observatory becomes better known. We would welcome correspondence and suggestions from American amateurs and schools.

HWU YEU PYNG
Liu Szu Ping Observatory
Pei Yuan High School
Kampar, Malaya

+++ AMATEUR BRIEFS +++

Manfred Kamintius reminds ATM's of Philadelphia's Franklin Institute that, although it is nice they know all about r^2/R and $r^2/2R$ and can discuss the virtues of the Maksutov versus Wright designs, they should not neglect the real reason for so much telescope knowledge and construction — astronomical observing.

For the past three summers the National Capital Junior Astronomers, Washington, D. C., has gathered and distributed astronomical observations made by many groups and individuals across the nation. Those interested in participating this year should write to Christopher W. Walker, 7101 Glenbrook Rd., Bethesda 14, Md.

George Hohnstein and Howard Schmadeke, of the Portland, Oregon, Astronomical Society, support the diagonal mirrors of their 6-inch reflectors on optical-glass plates, polished on both sides. They report that besides freeing images from spider-diffraction spikes the plates seal the tubes, keeping the mirrors clean and reducing convection currents. Light loss is minor.

Hoping to increase their membership to 100 by June 1st, the San Francisco Amateur Astronomers are advertising with 8-by-5-inch cards. They are on display in stores, hospitals, schools, libraries, and churches.

A member of Suncoast Moonwatch, St. Petersburg, Florida, asked Dr. Wernher von Braun when he had first seen Echo I. According to the club's newsletter, Dr. von Braun replied that he was at a party for the Russian delegation to the International Astronautical Congress in Stockholm. Someone who knew the satellite's time schedule invited the gathering out onto the terrace, where several 4th-of-July rockets were ready for firing. The chief of the Russian delegation, remarking that he had never seen the Americans fire a vehicle, handed over his cigarette lighter, and a rocket was lit. A few seconds later someone asked if it were yet in orbit. And over the horizon came Echo!

"Two wrongs can sometimes make a right," asserts Patrick Rizzo in the April *Eyepiece* of the Amateur Astronomers Association, Inc., New York City. Chromatic aberration caused by atmospheric refraction, which hinders observations of planets at altitudes up to 30 degrees with telescopes of moderate size, can be offset by decentering the object in the field of view. An eyepiece with considerable off-axis color, such as a Ramsden, will usually do the trick. Below 20 degrees altitude, it may not be possible to counter the atmospheric refraction in this manner; then a green filter can be tried, to suppress the red and blue images.

Many clubs exchange their bulletins. For example, the Hawaiian Astronomical Society trades issues with 24 groups in Colorado, California, New Mexico, and Arizona. G. B. C.

Space Science Resident Research Appointments

The Jet Propulsion Laboratory of the California Institute of Technology is accepting applications for resident research appointments in the space sciences. These appointments are open to U.S. citizens and foreign nationals. Security clearance is not required. Applicants must have training equivalent to that represented by a doctorate degree and must have demonstrated superior ability for creative research.

JPL has the responsibility of executing lunar, planetary, and interplanetary space exploration programs for the National Aeronautics and Space Administration, and is supporting research activities related to these programs.

The stipend for research appointments to highly qualified scientific personnel starts at \$10,000 per annum. For a foreign award, the basis would be equivalent to the salary of the researcher's American counterpart. An appropriate travel grant will be provided.

Applications will be accepted for positions in the following areas of research and development:

Instrumentation . . .

design, development, and preparation of scientific instruments for space research; research on and development of concepts and techniques applicable to space research.

Field and Particle Measurements . . .

gravitational, magnetic, and electric fields; ionospheres of the earth and other planets; energetic particles; micrometeorites.

Astronomy . . .

development of new astronomical instruments for use on space probes; cosmology; celestial mechanics.

Exobiology . . .

nature of extraterrestrial life forms; techniques of sterilization and decontamination of space probes.

Solar Physics . . .

solar-terrestrial relationships; measurements in the ultra-violet and x-ray regions of the spectrum; magnetohydrodynamics.

Geology, Geophysics and Geochemistry . . .

chemical and physical nature of lunar and planetary surface and subsurface material; study of lunar and planetary interiors.

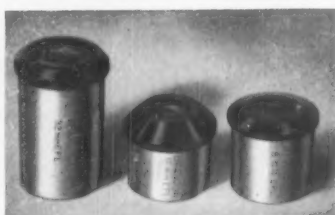
Planetary Atmospheres . . .

pressure, temperature, density, and composition of the atmosphere of the planets and the moon; the study of meteors and comets.

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OBSERVER'S PAGE

Universal time (UT) is used unless otherwise noted.

MARCH 2ND PARTIAL LUNAR ECLIPSE

AMATEURS from as far away as Ceylon have sent in observations of the March 2nd partial eclipse of the moon. Four early reports were noted on page 216 last month.

At Baton Rouge, Louisiana, Lewis M. Cook got up at 4:15 a.m. Central standard time, and took 21 photographs of the event with his homemade 3 1/4-inch refractor and 1 1/2-inch eyepiece. Four students at the South Dakota School of Mines and Technology, Rapid City, timed the disappearance of lunar craters into the earth's umbra with a 4-inch reflector. They were Howard Grams, Gary Schmidt, Donald Dunsmore, and Ken Carlisle. Clouds obscured the moon intermittently, but a total of nine timings was made before the sky became overcast at 5:50 a.m. Mountain standard time.

Gordon Solberg and Gene Johnston, Las Cruces, New Mexico, first suspected the penumbra near the southern edge of the moon at 4:16 a.m. MST. The color was a very light brown-gray. The umbra was seen at 4:51; at mid-eclipse it became gray-orange on the edge of the disk most deeply in shadow. Mr. Solberg took eight photographs, making most of his observations with a 6-inch reflector at 60x.

Five additional reports came from California. Two amateurs observed at La Mesa. Peter Hausteine watched from 3:30 to 6:00 a.m. Pacific standard time,

securing timings for first contact and the immersions of Grimaldi, Tycho, and Copernicus. Using a 3-inch f/10 reflector he found that all the major craters faded to invisibility within five minutes after entering the umbra, though the outlines of the seas remained clear. He took photographs of first contact and mid-eclipse.

Another observer at La Mesa was Mike Hudson. Two of his six photographs are reproduced here. In addition, he exposed the same negative every 10 minutes, obtaining 13 images that showed clearly the progress of the eclipse.

Michael DeFalco, at West Covina, commented on the reddish color of the moon, which was visible until clouds covered it at mid-eclipse. He used 8- and 4 1/4-inch reflectors and 6 x 30 binoculars. Donald Hudson, La Puente, took photographs with an 8-inch reflector, while in nearby Whittier Ronald Hoy took many Ektachrome pictures with a 12-inch reflector, from 4:00 to 5:21 a.m.

A. T. G. Brito writes from Jaffna, Ceylon, that the eclipsed moon was first seen nine minutes before mid-eclipse. He noted that the shadowed portion was unusually dark, though not invisible. The southern and southeastern limbs had a subdued orange hue.

An analysis has been made of 39 crater timings by amateurs in order to determine



Not long after the March 2nd eclipse began, Mike Hudson of La Mesa, California, took this picture of the umbral shadow encroaching on the crater Tycho (upper right) and the bright spot of Aristarchus (lower right).

the radius of the earth's umbral shadow. This turned out to be 3.6 per cent larger than its theoretical value — an unusually great enlargement. At the March 13th total eclipse last year, the figure was 2.7

per cent (see page 474 of the June, 1960, issue). Details of this analysis by Joseph Ashbrook will be submitted to *The Strolling Astronomer* of the Association of Lunar and Planetary Observers.

Mr. Hudson has here recorded the maximum phase of the eclipse, when only a slender crescent of the moon was outside the umbra of the earth's shadow. Just at its edge, below center in the picture, is the ring plain Plato, notable for its dark floor. A 4-inch reflector was used for Mr. Hudson's pictures, his Contaflex camera being coupled to the telescope for eyepiece projection.



SUNSPOT NUMBERS

The following American sunspot numbers for February have been derived by Dr. Sarah J. Hill, Whitin Observatory, Wellesley College, from AAVSO Solar Division observations.

February 1, 61; 2, 48; 3, 57; 4, 60; 5, 59; 6, 40; 7, 42; 8, 50; 9, 58; 10, 48; 11, 30; 12, 28; 13, 20; 14, 20; 15, 10; 16, 13; 17, 15; 18, 24; 19, 24; 20, 19; 21, 35; 22, 43; 23, 44; 24, 51; 25, 45; 26, 38; 27, 23; 28, 18. Mean for February, 36.5.

Below are provisional mean relative sunspot numbers for March by Dr. M. Waldmeier, director of Zurich Observatory, from observations there and at its stations in Locarno and Arosa.

March 1, 15; 2, 33; 3, 44; 4, 42; 5, 34; 6, 41; 7, 31; 8, 46; 9, 43; 10, 29; 11, 31; 12, 14; 13, 27; 14, 46; 15, 42; 16, 52; 17, 66; 18, 51; 19, 40; 20, 39; 21, 46; 22, 55; 23, 61; 24, 76; 25, 64; 26, 63; 27, 88; 28, 90; 29, 94; 30, 97; 31, 90. Mean for March, 51.3.

OBSERVATIONS OF ALGOL

Hector Ayala, of Ciudad Juarez, Mexico, reports naked-eye observations of the variable star Algol during four recent minima, on the nights of December 5, 25, and 28, 1960, and February 6, 1961, when he made 8, 12, 9, and 11 estimates, respectively.

From these observations, the following heliocentric Julian dates of minimum have been deduced, with the aid of the graphical method explained on page 190 of *SKY AND TELESCOPE* for February, 1957:

2,437,274.675	2,437,297.621
2,437,294.739	2,437,337.753.

These observed times of minimum give an average correction of only $+1\frac{1}{2}$ minutes to the Algol predictions that are

computed from the following formula:
 $J.D. Min. = 2,437,208.7224 + 2^d.8674E$,
 where E is the whole number of cycles elapsed since the initial epoch. This formula is the basis of the Algol ephemeris published on the Celestial Calendar page of this magazine each month.

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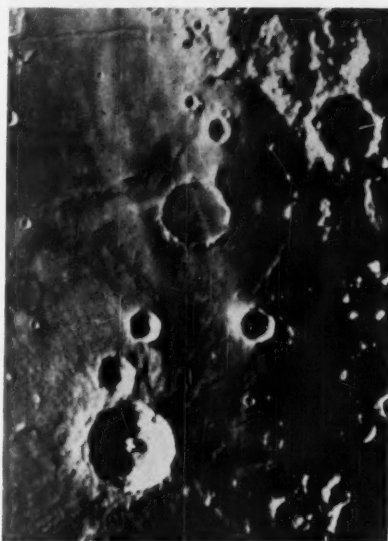
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OBSERVING THE MOON -- KIES

KIES is an interesting ring plain located near the southwest edge of Mare Nubium, a short distance south of Bullialdus. Approximately 28 miles in diameter, it exhibits traces of a polygonal structure, as do many other ring plains. The walls are ruined and low, their highest portions being on the east, where one peak (Kies α) may reach 2,500 feet. This height is perhaps equaled by the summit (Kies β) of a prominent spur attached to the south wall. As the accompanying drawing shows, the wall is not continuous, particularly on the east and west sides.

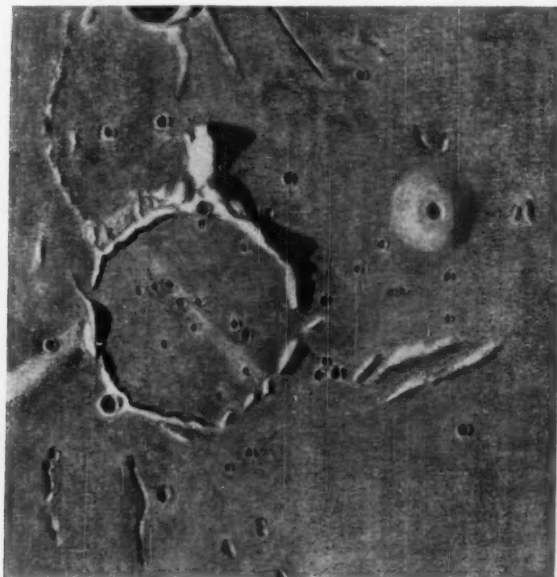
Inside Kies are many delicate craterlets, most of which can be well seen only in larger telescopes under favorable conditions of illumination and seeing. The floor is crossed by a bright streak which is part of the eastern component of the great double ray from Tycho. Within this streak, T. G. Elger discovered a minute and difficult rille, also reported by H. P. Wilkins, although W. Goodacre was never able to detect it. There are several other known examples of such an association between rays and rilles, in my opinion more than would be due to chance. Amateur observers with large instruments should search the lunar rays carefully for delicate rilles that may lie within them. I would be glad to receive detailed reports, including the date and time of each observation.

The plain surrounding Kies contains many fine details. Among these are low ridges, small isolated hills, fine clefts, and numerous small craterlets and craterlet chains that seem part of the splatter pattern surrounding Bullialdus. An interesting feature is a low, curved ridge that extends southward from the southwest wall of Kies, as may be seen in the photograph. I regard it as probably the remnant of an almost completely destroyed ancient ring.



The environs of the lunar crater Kies are seen in this part of a photograph taken with the Yerkes Observatory 40-inch refractor. Kies is above center. The large crater at bottom left is Bullialdus, and at top left is the well-known Hesiodus rille.

Perhaps the most noteworthy formation of the Kies area is the conspicuous swelling to the east of the crater. Long familiar to selenographers, it is a classical example of a smooth and symmetrical dome. According to my estimates, it is approximately eight miles in diameter, yet probably less than 1,500 feet high. The central third of the feature appears flattened, having a deep craterlet almost at the exact center. With its slopes inclined less than about four degrees to the level, this low swelling would present an inconspicuous silhouette against the lunar horizon to someone on the surrounding plain.



Compare this drawing by Alika K. Herring with the 40-inch refractor picture above. Observers generally agree that, under good seeing conditions, an experienced visual worker with a 12½-inch telescope can see more lunar detail than is recorded on photographs with very large instruments. Mr. Herring used 275x on August 2, 1960, at 3:30 UT. South is upward, east to the left. At the time of observation, the altitude of the morning sun was four degrees, as viewed from the crater's center. The illumination is nearly the same as for the Yerkes photo.

The aspect of the region varies greatly with changing illumination. Kies and the dome are conspicuous objects when the sun rises there, but fade rapidly into near-invisibility as it ascends. Around the time of full moon, the dome cannot be discerned at all, and the crater is indicated only by the dim and ghostly outline of its walls.

This portion of Mare Nubium will repay careful study. Obviously it has had a long and varied history, for it contains craters ranging from nearly obliterated formations to the cleanly cut and undamaged Bullialdus.

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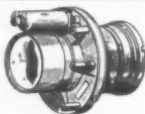
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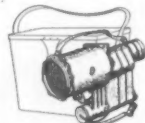
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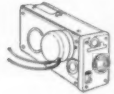
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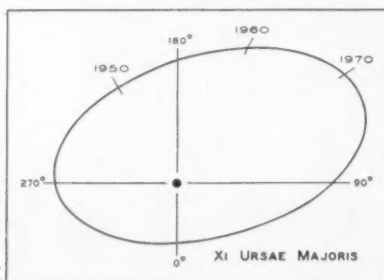
Xi Ursae Majoris, however, is one of the few systems resolvable in small telescopes that has an orbital motion easy to follow without special equipment. Its components are yellow stars of magnitudes 4.4 and 4.8, now separated by 2.2 seconds of arc. The period of revolution is 59.9 years. Actually the system is quadruple, as both the visible stars are spectroscopic binaries.

This remarkable pair was discovered by William Herschel in 1780. In his record book, under May 2nd of that year, he described it: "A fine double star, nearly of equal magnitudes, and 2/3 of a diameter asunder." Since almost exactly three revolutions have been completed since then, the present appearance of Xi is practically the same. This was the first visual binary for which an orbit was calculated, in 1827.

During the next decade, the distance of the companion will increase to a maximum of 3" soon after 1970, and then diminish to a minimum of just under 1" about 30 years from now. At present, the position angle is decreasing by about 3°.8 per year.

Serious measurements of the pair cannot be undertaken without a micrometer, either of the filar or the double-image type. However, position angle can be roughly measured by using a fine wire or spider line through the middle of the field of view. The observation consists of turning the eyepiece-and-line assembly until both stars are bisected by the line. An indicator mark on the ocular is read against a scale on the adapter tube. This scale may be merely a strip of finely divided graph paper pasted around the tube; count the total number of marks and compute the value in degrees of one division. A more elaborate indicator can be made with a protractor scale.

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care must be taken in finding the zero point of the scale. Unless you are using a permanently mounted equatorial in exact adjustment, the zero point must be determined immediately before measuring the double star. With the telescope stationary, turn the ocular until a star runs along the line across the whole width of the field. When this has been achieved by trial and error, you have oriented the line in position angles 90° and 270°. You can then find the point on the scale corresponding to position angle 0°, remembering that position angle is counted from north (0°) through east (90°), south (180°), and west (270°). A second check on the zero point just after the double star observation is a desirable precaution.

This simple method of measurement, although crude, is sufficient to show the change in position angle of Xi Ursae Majoris from year to year.

WALTER SCOTT HOUSTON
36 Lawn Ave.
Middletown, Conn.

A DAYTIME METEOR OVER NEW JERSEY

On March 17th at 4:33 p.m. Eastern standard time, I was preparing to observe Venus by daylight. Having sighted the planet with my unaided eye, I was slewing the telescope into observing position when a brilliant meteor passed across the field of the observatory dome's open shutter. It was about one magnitude brighter than Venus itself, making the meteor of magnitude -5.

It appeared to move parallel to the horizon at an altitude of 30 or 40 degrees, its path across the shutter being about 25 degrees long. Appearing as a fuzzy round blur, the meteor did not change in brightness as it traveled rapidly from northwest to southeast. No trail or train was visible.

I doubt I would have seen this meteor at all if the sky area had not been restricted by the dome and if my eyes had not been adjusted to the afternoon brightness by having searched out Venus.

RAYMOND J. STEIN
Newark Museum Planetarium
Newark 1, N. J.

MARCH OCCULTATION OF ALDEBARAN

WATCHERS in the western part of the United States were treated to the spectacle of the moon covering Aldebaran on the evening of March 21st. E. M. Brewer and Ted Cramer of Dallas, Texas, saw the event "exactly as predicted," and at El Paso R. B. Minton photographed the occultation with three cameras.

Carroll L. Evans, Jr., president of the China Lake, California, Astronomical Society, reported that Aldebaran's disappearance was at 4:58:20.2 Universal time on the 22nd, reappearance at 5:57:20.7.

The co-ordinates of his observing station were longitude 117°665 west, latitude 35°625 north, and elevation 2,285 feet. At Orange, California, Thomas C. Porter had good seeing throughout the event, securing times with a 3-inch reflector at 62x. His values were 4:58:34 and 5:59:48 UT. Donald Hudson, La Puente, commented that Aldebaran did not disappear suddenly, but faded gradually.

In nearby Hollywood, Emery Bernauer took 19 pictures on the same negative to show the moon approaching Aldebaran, exposing from 3:32 to 4:59 UT. Frank Trathen of Napa watched through a pair of 7 x 50 binoculars, seeing both immersion and emersion.

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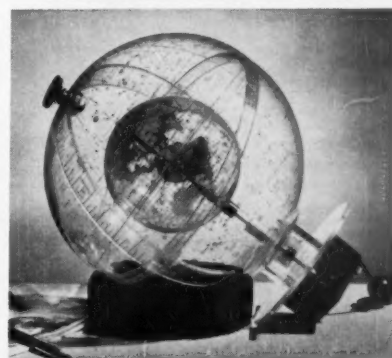
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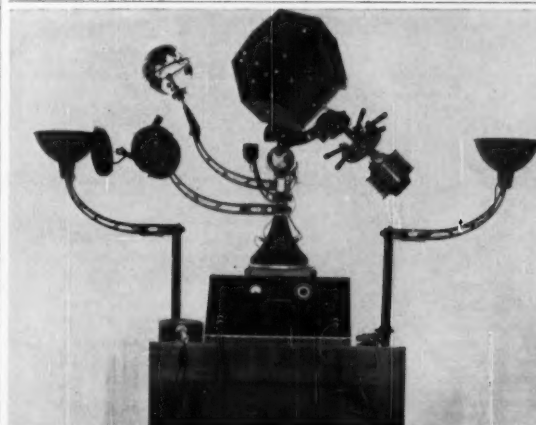
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MONTHLY REPORT TO OBSERVERS

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constellation of the month HERCULES

A crisp May night is an excellent time for exploration of the many telescopic wonders of the constellation Hercules, well up the eastern sky by late evening. The Kneeling Giant, clad in a lion skin and brandishing a huge club, is an extensive grouping of moderately bright stars, located between the Northern Crown and Vega, the latter now low in the northeast.

One of the finest showpieces in the heavens is the great Hercules cluster, Messier 13. It can just be made out with the unaided eye as a fuzzy star between Eta Herculis and Zeta. In binoculars or a view finder it appears a cometlike glow. A 3-inch UNITRON reveals it as a remarkable object, which is even more striking in a 4-inch. Viewed in a 6-inch, this famous globular cluster is a densely packed swarm of thousands of faint stars, a truly unforgettable sight.

Hercules is rich in attractive double stars for UNITRON users. An easy pair with a 2.4-inch refractor is Delta Herculis, 3rd magnitude with an 8th-magnitude companion about 9 seconds distant. A fairly high power is helpful in resolving this pair, because it brings the faint secondary star well clear of the bright primary's glare. Alpha Herculis is a beautiful double in a 3-inch UNITRON. Its brighter member is a 3rd-magnitude orange star, accompanied by another of magnitude $5\frac{1}{2}$ at a distance of 5 seconds. The strong color of the brighter star makes the companion look bluish by contrast.

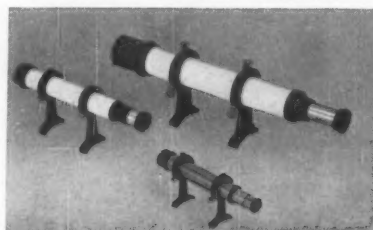
Another neat pair is Rho, magnitudes 4 and 5, separated by 3.8 seconds. It is readily split with a 3-inch, on a good-seeing night when star images are sharp even at high powers, and it can be divided with a skillfully used 2.4-inch.

Considerably more difficult than any of these is the famous binary star Zeta Herculis, consisting of two stars of magnitudes 3 and $6\frac{1}{2}$, 1.6 seconds apart. The companion takes 35 years to complete one revolution, and now, in 1961, the two stars are at practically their widest separation. This close, unequal pair is particularly rewarding with telescopes of high resolving power, such as the UNITRON 6-inch.

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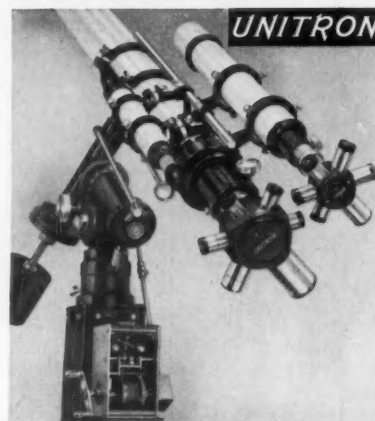


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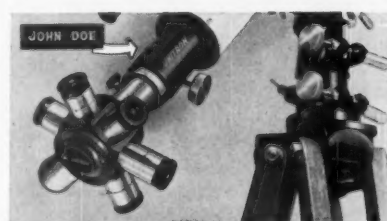
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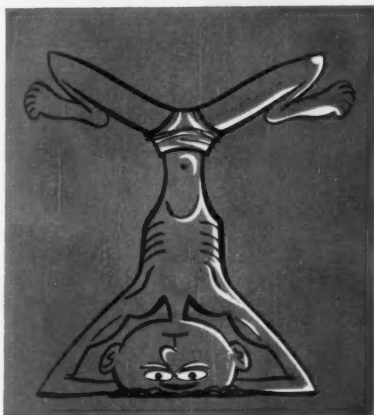


SECRETS OF YOGA UNCOVERED

Somehow or other, UNITRON's mailbag always seems to contain requests for information on a wide variety of subjects which range in content from aardvark to zymurgy. In particular, seldom does a week go by which does not see us receive an urgent request to clarify the principles of yoga. Rather than attempt any longer to handle these inquiries on an individual basis, we shall now reveal heretofore unknown secrets for the edification of the perplexed. Incidentally, while yoga does happen to be an ascetic discipline, an empty stomach is not a prerequisite for following the discussion; therefore, please feel free to help yourself at this time to an aardvark sandwich and a mug of zythum. Later, you may find that you have lost your appetite.

Perhaps the interest in yoga on the part of our astronomically minded correspondents can be explained by reference to the derivation of the word itself. *Yoga* comes from a Sanskrit word meaning to *yoke*. (We will ignore the jibes of would-be comedians who, for the purpose of impairing the seriousness of the discussion, might point out that linguistically the letter "j" is related to the letter "y.") The yoke, as owners of the UNITRON 4-inch Altazimuth Refractor will affirm, provides a sturdy mechanical support for many a telescope and is therefore a concept familiar to astronomers. Another word with the same linguistic root as *yoga* is *syzygy* . . . if you don't believe us, consult Webster . . . which the reader will recognize as the name of the points in the orbit of a celestial body at which it is in opposition to or in conjunction with the sun. Certainly, nothing more need be added to prove that we are on firm ground in maintaining that *yoga* is an important subject for a celestial discussion.

Briefly stated — and admittedly oversimplified — the student of *yoga* strives by mental concentration and suitable postures to identify himself, or become one, with the Universe. The practitioner who has mastered the subject is rewarded by a state of mental well-being that frees him from the cares of



the material world. Since elaboration of this theme along traditional lines would involve us in metaphysical muddles, we shall adopt a new approach which, we hope, will have more appeal to the scientific reader.

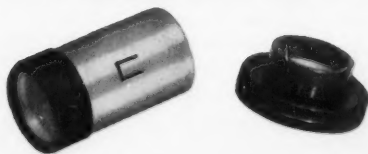
The fact is that the user of an astronomical telescope has a much better chance of grasping the essential principles of *yoga* than those to whom observing with a telescope is an unfamiliar experience. For after all, the observer, like the yogi who stands on his head, is accustomed to seeing the universe upside down. Admittedly, only the owners of certain types of telescopes, in which the optical design requires that the eyepiece be placed high up and on the side of a long tube, can share with the yogi the unforgettable experience of observing this inverted image while contorted in an anatomically awkward position. But, UNITRON owners should not become discouraged and feel that the bodily comfort they enjoy during their observing will prove to be a barrier to understanding. Not only will they not have to divest themselves of their UNITRONS but, as it will turn out, they have been yogis of a sort all these years without actually knowing it.

In the last analysis, the gymnastics are only a means to an end; the goal itself is the creation of an ineffable state of bliss which transcends ordinary experience. Now, what better way is there to describe the mental state of the UNITRON owner who night after night contemplates the universe through one of America's most popular refractors!

With a UNITRON, there are no mirrors to cool down while you cool your heels waiting for thermal equilibrium to provide a usable image; there are no optical elements which require periodic realignment or servicing; there are no rickety mountings to detract from the pleasure of observing. On the contrary, a UNITRON is ready to use as soon as you take it out of its cabinet, ready to reveal celestial objects with a clarity and definition that is truly breath-taking. (While breath control should really be discussed in any complete exposition of *yoga*, we shall apologize that limitations of space prevent a more exhaustive treatment of the subject.) And each and every UNITRON, from the smallest to the largest, is equipped with micrometric slow-motion controls to permit the observer to track an object with hardly any conscious effort, without distraction or detraction from the sheer pleasure of observing. This state of complete relaxation, this "oneness with the Universe" (to use the terminology of *yoga*), explains why so many UNITRONS will be found in active use by professional people, businessmen, engineers and others who seek release from the strain of daily problems in a hobby which, although relaxing, is at the same time mentally stimulating.

Neither the quantity of bliss in the Universe nor the number of UNITRONS in the Universe is fixed for all time. Fortunately, the supply of both can be expanded to meet the requirements of non-UNITRON owners who decide to join the favored fraternity. UNITRONOMY is not expensive, and even candidates on a yogi-type budget can usually afford to plunk down the ten per cent and meet the periodic paltry payments called for by UNITRON's Painless Payment Plan. Remember, every day many more people buy UNITRONS than take up *yoga* — there must be a reason!

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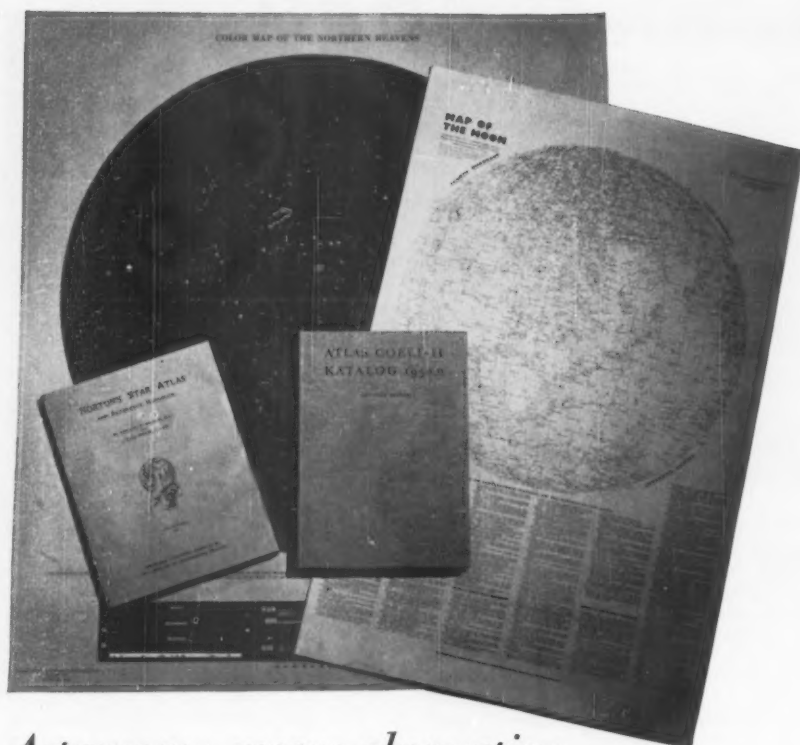
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Observers at their telescopes will find the inexpensive Field Edition of the Skalnaté Pleso Atlas a most convenient star reference. 16 sheets of stiff paper, 18" x 12 1/4", are printed in white on a black background, so they may be illuminated with a flashlight without spoiling the viewer's dark adaptation. The charts are unbound, \$4.00 per set; two sets for \$7.50.

Antonin Becvar's Atlas Coeli-II, Katalog 1950.0 is the most complete check list of celestial objects ever offered to the amateur observer. Given, with descriptive data, are the 6,362 stars brighter than magnitude 6.26, with their right ascensions and declinations, magnitudes, and much other useful information; extensive lists of star clusters, nebulae, and galaxies. Cloth bound, 367 pages, \$8.75. The catalogue makes a fine companion to the De Luxe Atlas of the Heavens, and they sell together for \$17.50.

Lunar observing is more informative with Elger's Map of the Moon, a large canvas-mounted chart identifying all important lunar features. Notes by H. P. Wilkins on 146 areas are given. The lunar chart itself is approximately 18" in diameter. \$3.00.

In two colors, and over 10" in diameter, the SKY AND TELESCOPE Lunar Map identifies most important features on the moon, including 326 mountains, seas, and craters. The map is good for use with groups at star parties: individual copy, 25 cents; 3 to 100 maps, 20 cents each; over 100, 10 cents each plus postage.

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Decorative as well as informative is the Color Map of the Northern Heavens, a large wall chart showing the northern sky in polar projection to declination -43°. Such important star groupings as Gould's belt, the Scorpius-Centaurus association, the blue stars of Orion, are all indicated by the star symbols, colored vividly to show spectral class. 30" x 34 1/2", only \$1.00.

Write for catalogue of all Sky Publications. All items, except where noted, sent postpaid. Please enclose your check or money order.

Announcing

CONSTRUCTION OF A MAKSTOV TELESCOPE

by Warren I. Fillmore

When his 6-inch Maksutov telescope was awarded first prize at the Stellafane competition last August, Warren I. Fillmore, secretary-treasurer of the Springfield Stars Club, was requested by members of the Maksutov Club to write a detailed account of his instrument. This he proceeded to do, for the benefit of amateur telescope makers all over the country.

Construction of a Maksutov Telescope is a 29-page booklet describing the ordering, grinding, testing, and assembling of the optical and mechanical parts of a Gregory-Maksutov 6-inch f/15 telescope. Ideas for accessories are also included. The author states that his essay "is no attempt to contend that the amateur engineering, about to be described, is the only way, nor even that it is necessarily the right way, to create one of these advanced instruments. It is simply a report on how I made mine, which fortunately turned out fairly successfully. I would hope that a few might find the following words helpful."

Printed by the photo-offset process, the monograph is illustrated with many photographs and drawings by the author, which depict testing equipment, optical paths in the instrument, lenses and mirror with their ground curves, Ronchi test patterns, and the completed telescope. A short bibliography is appended.

\$1.00

Amateurs thinking of constructing a 6-inch reflecting telescope are reminded of Allyn J. Thompson's **Making Your Own Telescope**. Complete step-by-step directions for making and mounting the instrument at low cost are given in easy-to-understand chapters. No complicated mathematics is involved, and no prior knowledge of optics is needed. 211 pages, 104 illustrations (7th printing).

\$4.00

Observing solar flares, spicules, and prominences is fascinating with the equipment described in R. B. Dunn's **How To Build a Quartz Monochromator**. 20 pages.

50 cents

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BOOKS AND THE SKY

TOOLS OF THE ASTRONOMER

G. R. Miczaka and William M. Sinton.
Harvard University Press, Cambridge,
Mass., 1961. 294 pages. \$7.75.

MODERN technological achievements have led to very rapid developments in astronomical instrumentation. Much of our recent progress in astronomy stems from these new techniques. This is especially true in the fields of radio astronomy and photoelectric photometry.

Sixteen years have elapsed since the publication of Dimitroff and Baker's *Telescopes and Accessories*, and a revision or modernization of it has been urgently needed for some time. G. R. Miczaka and W. M. Sinton have done this in an excellent, detailed, but nonmathematical book which will be found useful to professional and amateur astronomer alike. It is one of the Harvard Books on Astronomy.

The astronomer's task is to collect, analyze, and interpret electromagnetic radiation from outer space. It is appropriate, therefore, in a book of this kind, first to acquaint the reader with the fundamental properties of such radiation. This is done in a very readable opening section. Succeeding chapters deal in turn with photography, telescope optics and construction, photometry, spectroscopy, solar instruments, and radio telescopes.

Limitations of text length have restricted the contents to those techniques and instruments that are finding extensive modern application. Further, image tubes and rocket-borne, balloon-borne, and satellite-borne equipment have been deliberately omitted. However, a remarkable number and variety of instruments are discussed. I found the 32 pages on radio telescopes especially interesting and informative.

The most important and widely used astronomical instruments (from the point of view of an optical astronomer) are probably the slit spectrograph and the photoelectric photometer. The book's discussions are comparatively weak in both instances.

For example, the authors state, "If high resolving power is desired, large prisms or gratings are necessary and they must be fully illuminated." This statement avoids the main issue, which is that a large collimated beam is necessary to increase the efficiency of a spectrograph. The resolving power is normally fixed by that of the photographic plate, which in turn sets the size of the width of the slit image at the plate (usually about 0.02 millimeter). This determines the actual slit width, whose ratio to the slit-image width is proportional to the ratio of collimator focal length to camera focal length. With a given angular dispersion, the camera focal length is fixed by whatever linear dispersion is desired. Therefore, the longer the collimator focal length, the more the slit can be opened; also, the wider the collimated beam is, the more massive and expensive the spectrograph becomes.

These spectroscopic facts of life underline the importance of the large, stable, and highly efficient coude spectrographs. They are a necessity for large reflectors, and could even be very useful with relatively small mirrors (around 30 inches in diameter), not only for spectroscopy but for narrow-band photometry.

The discussion of photoelectric photometry might well be strengthened by including the spectral responses of both a red-sensitive cell and a lead sulfide cell, narrow-band photometry and spectrum scanning, Hiltner's seeing-compensated polarization technique, and a less sketchy and more up-to-date discussion of standard magnitudes and colors.

I do not want to seem overly critical, for it is obviously impossible, nor would it be desirable in a book of this length and at this level, to satisfy specialists in all fields of observational effort. The authors have done a prodigious job in condensing and simplifying material from many widely separated sources.

JOHN B. IRWIN
Goethe Link Observatory
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Star Atlases and Books on Astronomy

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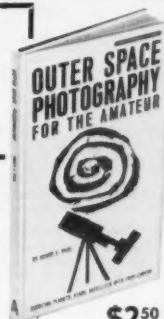
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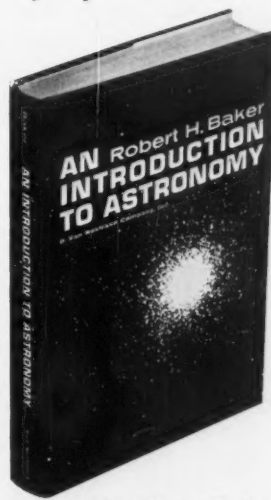
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The *Photographic Lunar Atlas* is compiled from the best photographs taken at Mount Wilson, Lick, Pic du Midi, McDonald, and Yerkes observatories, edited by G. P. Kuiper with D. W. G. Arthur, E. Moore, J. W. Tapscott, and E. A. Whitaker. 250 sheets, 17" x 21", contain 281 photographs. A 23-page explanatory booklet is furnished.

Part One is 11 sheets showing subdivisions of the lunar surface into 44 fields. The sheets are loose leaf so that they can be used with the main body of photographs in the atlas and then returned to the box. Names of maria, mountain ranges, and craters follow the 1935 IAU atlas.

Part Two is the main body of the work, and is composed of 184 sheets. There are four sheets per field, and two sheets for each of four fields. Altogether, there are 212 pictures of the 44 lunar subdivisions.

Part Three consists of 35 sheets (63 photographs) giving additional coverage to the 44 areas. **\$30.00**

ORTHOGRAPHIC ATLAS OF THE MOON — PART I

Covering the central part of the lunar disk, this is the first of two supplements to the *Photographic Lunar Atlas*. It consists of 29 orthographic charts with grids, the interval being 0.01 lunar radius. Accurate positions of lunar features are easily read from these maps. The limb regions will be published later. (See review in *April Sky and Telescope*.)

Edition A: Printed on high-grade paper with south at the top (for astronomical use). **\$9.00**

Edition B: Printed on Tensalex, a washable, tear-resistant, heavy plastic. Has the grids plus overprinted blue latitude and longitude lines for every two degrees. North is at the top of each chart. **\$15.00**

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Associate Astronomer
American Museum-Hayden Planetarium
AT MUSEUM AND PLANETARIUM SALES DESKS

OUTER SPACE PHOTOGRAPHY FOR THE AMATEUR

Henry E. Paul. Amphoto, New York, 1960. 124 pages. \$2.50.

THIS is a small volume, but one that will delight the novice and inspire the advanced amateur astronomer. In his remarkably clear style, Henry E. Paul outlines what can and cannot be done by those unafraid to tackle a new and challenging area of photography. The book is profusely illustrated with fine photographs taken by amateur astronomers throughout the world. The author's travels and correspondence enabled him to gather the best examples of each kind of astrophotography and to add comments gleaned from conversations with literally hundreds of workers in this fascinating hobby.

In the introductory chapters, Dr. Paul outlines the requirements for good celestial photographs, pointing out the various areas open to amateur work and showing pictures taken with cameras of 1- to 20-inch aperture. His approach here is valuable — the beginner learns that some astrophotography requires only small cameras or lenses and little or no mounting and drive equipment. At the same time, however, it is made clear that first-class work on planets, galaxies, and nebulae calls for a large telescope and excellent optics, with a mounting and sidereal drive that prevent vibrations and give fine star images.

The discussion of lenses, telescopes, and films is brief but specific, and those desiring more detailed data are referred to Dr. Paul's chapters in *Amateur Telescope Making — Book II* and *Book III*, as well as to other sources. To conserve space for photographs, the author has written concisely, making special recommendations on the equipment he has personally found most useful. A valuable appendix lists instrument suppliers and information sources.

The amateur is introduced to star-trail, rocket, and satellite photography. Since recording these objects requires only a conventional camera, they serve as a fine beginning point for astrophotography. The author rightly stresses use of a firm tripod for all work with telephoto lenses, but he might well have pointed out the advantages of short focal lengths for satellite photography. Such lenses are often faster than telephoto ones, giving a stronger image and a greater exposure time to each point of the path. Of course, no lens whatever will show any details on a satellite.

Photography of the moon is a logical next step. Dr. Paul recognizes the differing requirements of lunar photography when he suggests Micro-File (high contrast) film for use on the full moon, and Panatomic-X (lower contrast) for recording the subtle shadings of the other phases. Micro-File or even slower films are also recommended for solar pictures. Here

light for exposure is no problem (indeed, it is easy to burn film, shutters, or eyes if proper precautions are not taken), and a slow, fine-grained film of high contrast is desirable to show sunspot details.

Color film is mentioned in several chapters, particularly in connection with photography of the aurora, sun, and eclipses. Only recently have there been available color films fast enough for good celestial photographs, and more discussion of this new field would have been valuable. The surface features of Mars and Jupiter are often recorded with better contrast and clarity on color film than in black and white. Dr. Paul does note that colored filters with black-and-white film are useful in planetary photography as well as for distinguishing the hues of stars. Color photographs, however, are easier to interpret and can produce valuable and beautiful results with Mars, Jupiter, the aurora, and (at long exposures) the brighter nebulae.

The chapters concerning photography of star fields and nebulae are illustrated with some of the finest amateur photographs ever taken. Exposures up to four hours are needed for these objects; in some cases a 20-inch telescope was used. Obviously the average amateur must be simultaneously inspired and discouraged on seeing such remarkable pictures. It seems, however, that inspiration usually prevails, for the quality of amateur astrophotography is steadily improving.

The concluding chapter, on planetary photography, is rightfully less specific in recommending films and procedures. Brightness, image size, and atmospheric turbulence vary greatly in this work, so only rough estimates can be given. A unique picture set by Horace Dall of England shows dramatically the loss in planetary-image resolution as telescope size is decreased. As in photography of faint nebulae, a telescope of at least 6-inch aperture equipped with a good drive is probably essential.

Although space is always at a premium, Dr. Paul might well have expanded the appendix sections on optical formulas and equipment suppliers. Nevertheless, this book contains more practical advice, use-

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GEORGE T. KEENE
Rochester Academy of Science

MICHELSON AND THE SPEED OF LIGHT

Bernard Jaffe. Doubleday and Co., New York, 1960. 184 pages. 95 cents, paper bound.

THIS PAPERBACK, one of a dozen or so commissioned to accompany the Physical Science Study Committee's educational program in physics, is appealing to both the amateur scientist and the inquiring student. Its contents, especially if used with the committee-designed physical science course, will aid in letting interested boys off the classroom leash and into physics on their own. Amateur astronomers, too, may welcome this chance to review the subject's fundamentals.

No mere history of the life of Albert A. Michelson, the book gives an insight into the methods by which science advances, and shows the character of a scientific investigator. Students who have learned in class about refraction, interference, and diffraction gratings, will here be able to associate such things with a real scientist.

Briefly, we discover Michelson as a raw youth from the West, fiercely determined to make his way in the world. After specializing in physics at the U. S. Naval Academy in Annapolis, he returned there as an instructor.

In 1876 an Englishman, John Tyndall, lectured in America on light and, incidentally, on the value of pure research. This inspired Michelson to improve, modify, and refine earlier experiments on the speed of light, obtaining more accurate results than ever before.

While traveling in Europe after 1880 and studying under the great scientists of that day, Michelson became intrigued with the postulate of the ether and decided to try to measure its effect on the speed of light. His genius produced a device, the interferometer, to help him with the microscopically small measurements he expected to encounter. In the face of contrary opinions of great men, he was brave enough to call the hypothesis of a stationary ether erroneous.

Back in America, at the Case School in Cleveland, he associated with Edward W. Morley in a renewed effort to discover an ether effect, this time postulating a moving ether, but again the results were negative. Fizeau and later Einstein depended on this famous experiment for their theoretical innovations.

Michelson's attentions turned to an idea of using the wave lengths of certain spectral lines as units of length. He measured the standard meter at Sèvres against light waves. In 1890, while at the University of Chicago, he worked in spec-

troscopy, then in its infancy, and sought to improve diffraction gratings and ruling engines. The Nobel prize in physics was awarded Michelson, the first American to be so honored, in 1907, for his "exactness of measurement" and "investigations in spectroscopy."

Subsequent work included the application of the versatile interferometer to the measurement of apparent stellar diameters. In 1931 he died, after a return to his earliest interest — more exact measurements of the speed of light, both in air and in vacuum.

Michelson's character invites admiration. He shows the care, patience, and exactitude required, beyond all usual bounds, by a career in refined experimentation. This book portrays vividly the destruction of the ether hypothesis by scientific observation, and the difficulty with which human thought, accustomed to the loose and comfortable fit of theories grown old without attack, readjusts to new proofs.

KEITH D. PALMER
Episcopal Academy
Merion, Pa.

CORRECTION

On page 227 of the April issue, the scale of the *Orthographic Atlas of the Moon* should have been given as approximately 1:1,370,000, not 1:3,700,000. This error was pointed out by Don Brabston, Jr., Birmingham, Alabama.



Astronomy Teaching Aids

ESSCO Publications

Teachers of astronomy, both amateur and professional, will find the following ESSCO study materials useful for their classes. The test charts are challenging fun for the amateur astronomer, too!

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- SC2 Circumpolar constellation chart — with star designations
- SC2T Test circumpolar chart — without star or constellation names
- SS08A Ecliptic-based star map — with equatorial grid and names
- SS08 Ecliptic-based star map — with equatorial grid, without names
- SS08B Ecliptic star map list — positions and magnitudes for 224 stars
- SS05 Nine-inch protractor on paper — for planet orbit drawings
- SS11 Inner planet chart — orbits of Mercury, Venus, Earth, Mars
- SS12 Outer planet chart — orbits of Mercury to Saturn
- SS01A Special rectangular co-ordinate paper — for star maps
- SS02 Polar co-ordinate paper — for circumpolar star maps
- S600 Aitoff's equal area projection of the sphere — 13 inches wide

Price for each item listed above: 1 to 9 sheets, 10 cents each; 10 to 24 sheets, 8 cents each; 25 to 99 sheets, 6 cents each; 100 or more, 5 cents each.

From Stetson's *Manual of Laboratory Astronomy*, the chapter "Star Chart Construction" is available as a separate booklet, at 50 cents per copy.

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NEW BOOKS RECEIVED

VORSTOSS INS UNBEKANNTE, Werner Büdeler, 1960, Ehrenwirth Verlag, Vilshofener Strasse 8, Munich 27, West Germany. 342 pages. DM 19.80.

Advance into the Unknown is a popular illustrated review, in German, of the progress made in various sciences during the International Geophysical Year.

THE TECHNIQUE OF OPTICAL INSTRUMENT DESIGN, R. J. Bracey, 1960, Macmillan. 316 pages. \$9.00.

In this detailed mathematical review of the principles of geometrical optics, their application to the design of optical instruments is continually emphasized. There are chapters on ray tracing, aberrations, and the fundamental features of telescopes, periscopes, and microscopes.

THE WORLD AROUND US, Sir Graham Sutton, editor, 1960, Macmillan. 122 pages. \$3.95.

Six lectures delivered to an audience of young people at the Royal Institution in London gave a summary of the International Geophysical Year in 1958. They have been expanded by their authors into essays reviewing areas of intensive IGY research, including the ionosphere (J. A. Ratcliffe), the earth's magnetic field (J. M. Stagg), and the upper atmosphere (R. L. F. Boyd).

MODERN SPACE SCIENCE, Frederick E. Trinklein and Charles M. Huffer, 1961, Holt, Rinehart and Winston. 550 pages. \$4.96.

This high school science textbook contains units on matter in the universe, physical laws, elementary astronomy, and man in space. Dr. Huffer is professor of astronomy at the University of Wisconsin.

TELESCOPES AND OBSERVATORIES, K. V. Bailey, 1960, Frederick Muller Ltd., 110 Fleet St., London, EC 4, England. 144 pages. 9s 6d.

This summary for the casual reader combines bits of astronomical history with descriptions of optical telescopes past and present. There are two chapters on radio astronomy and a brief final one on observatories in space.

BINOCULARS AND SCOPES, Robert J. and Elsa Reichert, 1961, Chilton Co., 56th and Chestnut Sts., Philadelphia 39, Pa. 128 pages. \$2.95; paper bound, \$1.95.

For the many sky observers who use binoculars and spotting scopes, this book provides a guide to instrument purchasing and handling. Such topics as power and field of view are discussed in their practical applications, and an extensive section on terrestrial photography concludes the book.

SMITHSONIAN TREASURY OF SCIENCE, Webster P. True, editor, 1960, Simon and Schuster. 3 volumes, 1,208 pages. \$15.00.

From the reports of the Smithsonian Institution comes this selection of 50 scientific articles by eminent authors in fields ranging from aeronautics to zoology. Astronomical contributions include chapters on the time scale of the universe (E. J. Opik), solar flare effects on the earth (J. W. Evans), radio astronomy (G. S. Hawkins), Mars (H. P. Wilkins), meteors (F. L. Whipple), and cosmic rays (W. F. G. Swann).

BALLOONS FLY HIGH, Lynn and Gray Poole, 1961, McGraw-Hill. 72 pages. \$2.75.

Delightfully illustrated accounts of men's adventures with balloons since 1783 are presented for children of grade school age.

TURNING POINTS IN PHYSICS, R. J. Blin-Stoyle, D. Ter Haar, K. Mendelssohn, G. Temple, F. Waismann, and D. H. Wilkinson, 1961, Harper. 192 pages. \$1.45, paper bound.

A series of lectures at Oxford University in 1958 reviewed critical points in the evolution of modern physics. Now in essay form, the historical studies include the quantization of matter, the advent of probability, and the decline and fall of causality.

CAPTURED STARS, Heinz Letsch, 1959, Gustav Fischer Verlag, Villengang 2, Jena, East Germany. 183 pages. DM 16.00.

Das Zeiss-Planetarium was published in 1949. This is the first English translation, by Harry Spitzbardt. Profusely illustrated, it discusses the principles of Zeiss planetarium construction and describes many installations throughout the world.

HANDBUCH FÜR STERNFREUNDE, Günter Dietmar Roth, editor, 1960, Springer-Verlag, Heidelberger Platz 3, Berlin-Wilmersdorf, West Germany. 360 pages. DM 48.

Handbook for Amateur Astronomers is a co-operative work by nine German astronomers, giving details of instruments and observing techniques for practical work on the sun, moon, planets, comets, and variable stars. There are many tables of useful data and an extensive bibliography.

THE STROLLING ASTRONOMER

The journal of the international Association of Lunar and Planetary Observers (A.L.P.O.). Illustrated with drawings, charts, and photographs by members. Founded in 1947. Directed to the advanced amateur specializing in the study of the moon, planets, and comets.

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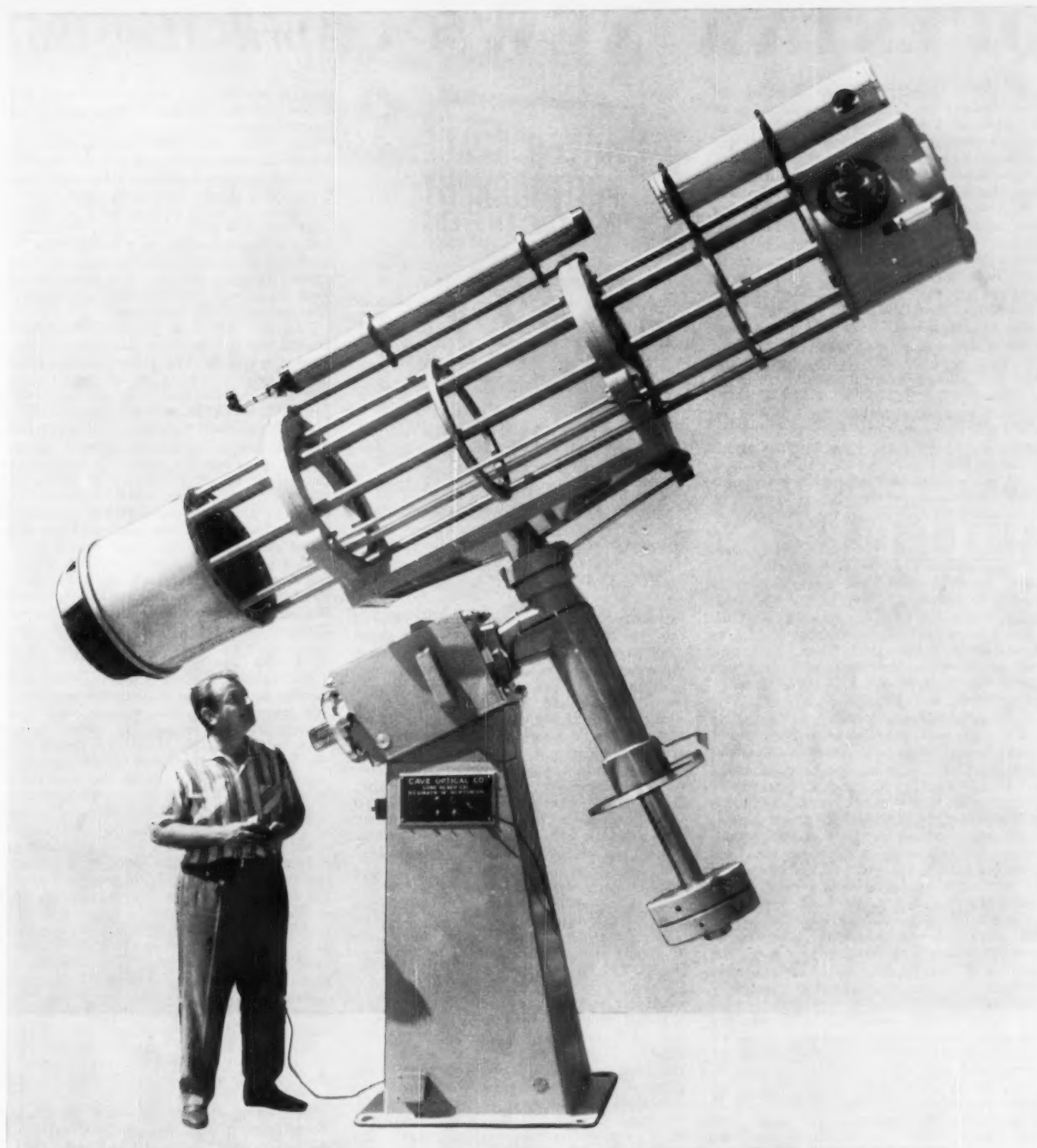
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QUESTAR NEWS • April-May, 1961

In 1955 a Questar was purchased by the world-famous Dr. C. E. K. Mees, Director of the Eastman Kodak Research Laboratories. What especially pleased us at the time was his remark to a colleague that "he had bought it because it had the finest diffraction image he had ever seen outside of textbooks."

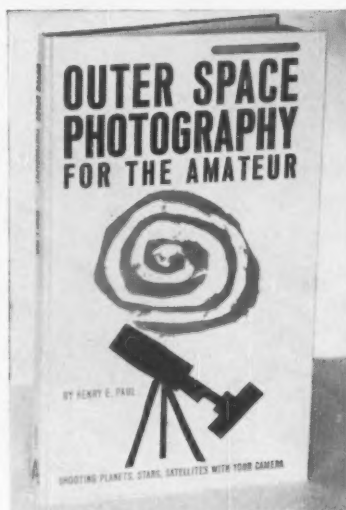
As you probably know, we decided a long time ago to protect the privacy of each Questar owner. We do not disclose their names and addresses, never send prospects to their door, or ask them to act as demonstrators for our product. Many Questar owners have especially asked us to send prospects to them, and have sometimes been annoyed by our refusal to do so, for we still think it is the only nice way of dealing with our clients over the breadth of years to come.

There have been times when we wished we could tell the world that Dr. Mees was enjoying his Questar and used it often at his home in Hawaii, to which he had retired. With his passing last summer, we can now speak freely and mention that in his will he bequeathed his Questar to the University of Hawaii.

Perhaps we have been too strict about mentioning famous people who own Questars. Most of them have adequate privacy shields as a matter of course. So we might mention that the Cary Grants own two Questars. Mr. Grant explained that they have three houses — his wife has one, he has one, and they have one, so that is why he bought the second Questar. We hope this is clear — three houses, two Questars.

Questar's offices and plant are located in open country three miles from New Hope, Pennsylvania. This is 65 miles southwest of New York and 40 miles due north of Philadelphia. We had to find another secretary by February 1st this year, and found ourselves envying city folks, because good capable secretaries who can run IBM executive typewriters do not seem to grow on our local trees out here in the sticks. After two weeks of interviews, we found Miss Janet Gemmill splendidly qualified, praise Allah, and living in a nearby town. As we tried to explain her duties in the telescope business, we mentioned that long-distance calls were frequent and occasionally we had distinguished visitors. At once we realized our error — the likelihood, of course, was that all calls for the first week would be local ones and the only visitor the trash man. But on her first day every call we had was transcontinental, and who should walk in to take delivery of a Questar but Dr. L. E. Flory from Princeton and the great Dr. V. K. Zworykin, who perfected television. And why were these distinguished gentlemen choosing a Questar that day? Dr. Z. said that, having completed the fantastically accurate automatic control and guiding system for the Stratoscope II 36-inch balloon-borne quartz telescope project, they were now about to tackle the control system for a larger manned telescope in a space vehicle which will operate from orbit. For convenience the system will point the little Questar instead of the huge machine it will eventually control. What a wonderful business this is when it gives us such glimpses of the instrumental frontier!

But our business has other days too. We are coming to think of the daily struggle for quality control as the Battle That Is Never Won. We find that we have 102 suppliers, and constantly riding herd on so many separate sources turns out to be no small task.



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Inspection, of course, is the answer. But it can be mighty inconvenient when about 4,000 parts arrive from three separate sources the same afternoon. This means that somebody has to stop making Questars and become inspector. We have to check every piece or spot-check every shipment as soon as it arrives, to make sure it is right before we accept it and put it into inventory.

About once a week some supplier goofs on something he has been making perfectly for years. Sometimes several things go wrong at once. These are the days we are apt to wonder what keeps the whole economy glued together. What brings on this lament? The fact that yesterday our production manager had to spend his entire day at the plant of a distant supplier getting his boys back on the rails again.

We are pleased to tell you that on January 17 the Hayden Planetarium, of the Museum of Natural History in New York, took delivery of a Questar which will be used for evening classes in astronomy.

It has always seemed to us that Questar was an ideal kind of instrument for any school. It can be stored in its case on the microscope shelf, there is no upkeep for dome or shelter, while it has no equal as a convenient clock-driven demonstration instrument. It is good to report that more and more schools are finding this out. The public schools of San Diego recently purchased three more Questars, Yuba City High in California bought one, and Southern Connecticut State College in New Haven is taking another four.

In addition to several sales to individuals in Italy last year the Osservatorio Astronomico di Capodimonte recently bought a quartz-mirrored Questar outfit with large solar filter and camera. The Royal Institute of Technology in Stockholm purchased another, and the Dominion Observatory in Canada has just taken delivery of two quartz Questars.

In scanning our client registration book we find so many institutions have become Questar users that it would bore you to hear much more about them. We do note that several went to Atomic Energy Com-

mission installations, and several were purchased by the National Aeronautics and Space Administration.

The Naval Air Development Center at Johnsville, Pennsylvania, is not far from us, and they have had a Questar for some time. Remarkable strides have been made there in miniaturizing aerial photographic equipment with an actual gain in efficiency. The standard size film is no longer 9 inches wide but is now the 70-mm. kind, as used in wide-screen movies. We see and hear aircraft from their field both day and night, taking pictures under all conditions.

Recently the team of astronauts being readied for space travel has been training there. Captain Benson, a Navy doctor working on space problems, set up their Questar and was pleased to find he secured fine photographs in both black-and-white and color of the November 7 transit of Mercury. We spent a fascinating afternoon with Captain Benson at Johnsville testing Questar in the circular centrifuge building that houses the gigantic rotating arm which simulates the effects of gravity on accelerating objects. As you may know, Questar pioneered the thin-edged mirror disk supported wholly at the thicker circumference of a central hole. For space vehicle installations the question of this construction's sturdiness had come up. We can now tell anybody interested that any Questar will stand 36 g's axially in either direction without damage. And that is all the g's the centrifuges put out.

Did you know Navy pilots have for many months been wearing a workable space suit? We were assured this was so, and were shown a lightweight rig with helmet stretched on a long table. To demonstrate the suit's normal attitude under pressure a pump was started, causing the empty helmeted figure to move in eery fashion as it inflated. Once more we experienced a sense of disbelief: We have heard of the vacuum-proof suit for 30 years, and it now is here.

From the Army installation at Fort Monmouth came most gratifying news in January. An engineer called us and said that the staff of lens and photographic specialists there had been amazed at the performance of a Questar just delivered to them. It was, said he, consistently resolving 1 second of arc easily instead of the 1.4-second Rayleigh or 1.3-second Dawes rating for its 3.5-inch aperture. It was beating the resolution obtained from four catadioptric photographic lenses of from 40 to 150 inches focal length, all of larger aperture. Further, he said, their optical system expert had never seen so fine a diffraction image.

We made a date and in a few days a delegation arrived to ask us how we did it. All we could tell them is that it is a question of policy. We think our business future depends on quality, and the pursuit of quality is perhaps half a matter of determination and the other half a matter of conscience. Yes, it hurts to discard the almost-perfect set of optics, or the piece of metal that is just a little off. It is costly and often worrisome. But it is the only way a Questar can be made.

Lawrence Braymer, President



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GLEANINGS FOR ATM's

CONDUCTED BY ROBERT E. COX

AN OBLIQUE REFLECTOR AS A FIRST TELESCOPE

AFTER PLANNING for many years to build a 6-inch Newtonian as my first telescope, I decided instead to make a 4-inch oblique reflector similar to Anton Kutler's 4.3-inch "Schiefspiegler" pictured on page 66 of the December, 1958, *SKY AND TELESCOPE*. I read Gleanings *Bulletin A*, in which Mr. Kutler describes the optical and mechanical principles of this type of instrument.

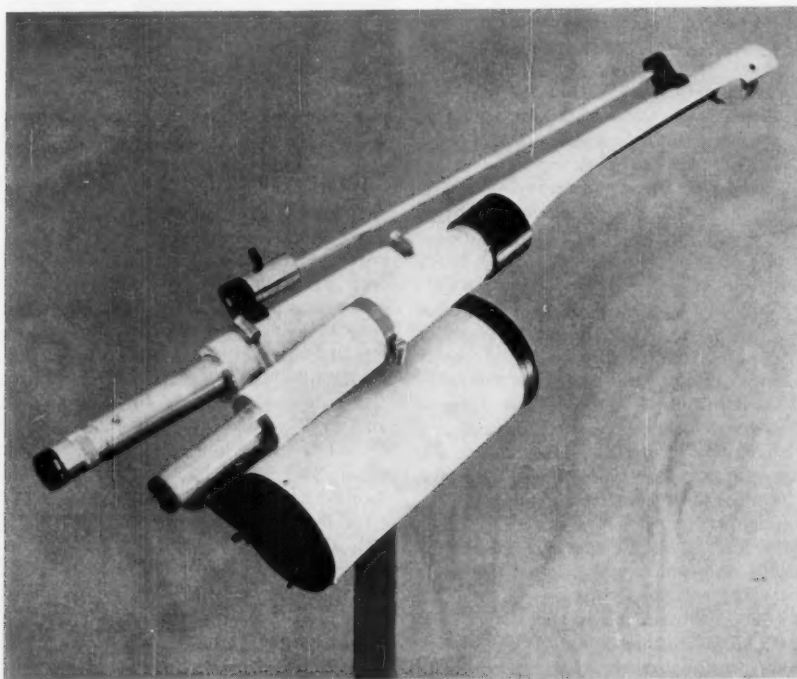
The perfect achromatism of a mirror system is combined with the unobstructed optical path of a refractor. This promise of superb optics and the simplicity of design lured me from the traditional starting point of amateur telescope makers. I would imagine that the two spherical mirrors of the oblique reflector offer less difficulty to the beginner than a paraboloidal mirror for a Newtonian reflector.

The telescope is Cassegrainian in form, having an $f/12$ spherical primary and a convex spherical secondary that increases the focal length by a factor of only 1.67 or thereabouts. To avoid any obstruction of the incoming light rays, the secondary is placed to one side where only off-axis bundles can reach it. These suffer from both astigmatism and coma, but by tilting the secondary away from the primary's direction, astigmatism and coma of oppo-

sition sign are introduced. With the proper inclination, the secondary can be made to cancel exactly either one or the other aberration, but not both. The remaining defect must be corrected with an aspheric secondary, or simply by limiting the size of the instrument, as I did.

Mr. Kutler has shown that if the secondary is adjusted to eliminate astigmatism, the coma will be negligible for an aperture of $2\frac{1}{2}$ inches or less. This would make too small a reflector even for a first telescope. But by "cheating" a bit on the position of the secondary, moving it in so it slightly obstructs the incoming rays to the primary, the coma is negligible for a 4-inch aperture. No more than three per cent of the primary's area is blocked, causing no diffraction damage, as would be the case with a centrally supported secondary. The resulting system is said to rival a 4-inch apochromatic refractor, a very fine instrument.

Grinding and polishing the mirrors went very smoothly, except for exasperating failures in trying to cut a conventional square-facet pitch lap. I finally used a rubber lap mold similar to the one described by Allyn J. Thompson in *Making Your Own Telescope* (page 54). Such a lap is so easy to make and performs so



The assembled off-axis reflector of C. B. Avera, Jr., on its temporary pipe-fitting mount. The large short tube contains the primary mirror, which reflects light to the secondary at top right. From there the light goes obliquely into the cutaway tube that bears an adjustable sliding weight. This compensates for the change in balance when a single-lens reflex camera is substituted for the eyepiece at the extreme left. In the center is a 2-inch finder.

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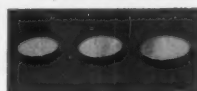
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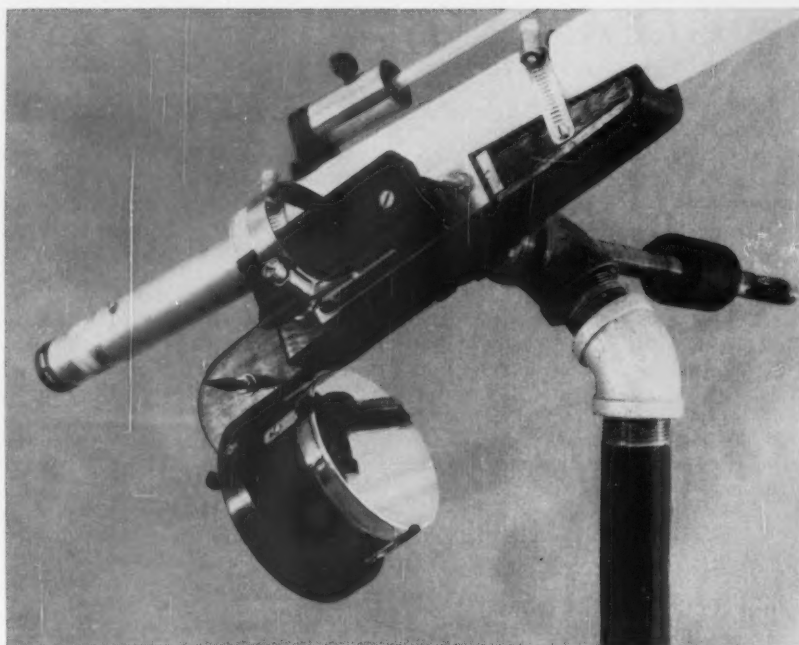
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The finder and the 4-inch mirror's protective tube have been removed to reveal construction details. The wooden saddle maintains the proper angle between primary and secondary, while the hose clamps may be loosened to permit shifting of the secondary tube along its length. This is done in final alignment, when the distance of the secondary mirror from the primary is adjusted to the correct amount. Photographs by the author.

well that I shall probably never use any other type.

I figured the secondary mirror according to Mr. Kutter's suggestion in this department for April, 1959, page 348. The secondary should be made of optical glass, its back being ground and polished flat to within half a wave. The Foucault test is made through the back, the inside of the convex surface reflecting the light as if it were a concave mirror. The actual radius of curvature is shortened by refraction, the factor being approximately equal to the reciprocal of the glass index of refraction. For an index of 1.5, the shortening is to two thirds of the real value.

To avoid working an optical flat, I cut two disks nearly two inches in diameter from a section of Edmund "flat glass." Using a piece of old plate-glass mirror as a third surface, I tested all four sides of the disks, finding two that were flat to better than a half wave. One of these was selected to be the back of the secondary, the other disk being made the tool. Although I did not know the exact index of refraction of the glass, and therefore could not compute the actual radius of curvature of the secondary, I proceeded to obtain as perfect a spherical surface as patience would permit. At the end of fine grinding, to get an estimate of the radius of curvature, I put a "quick shine" on the tool, using an HCF lap and fine emery; after a few minutes of polishing the tool's radius could be measured directly on the Foucault tester. The desired radius was 105 inches, which increased to

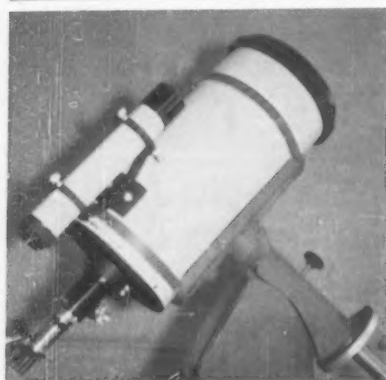
108 inches during polishing of the mirror.

This longer radius reduced the actual effective focal ratio to f/19 instead of f/20, but that was of little consequence. When the mirrors are in proper adjustment, the instrument splits doubles closer than Dawes' limit for a 4-inch aperture. Its brilliant performance on lunar and planetary detail is truly amazing.

The mechanical construction of an oblique reflector is more complicated than that of conventional instruments, as shown by the pictures with this article. The primary mirror cell is an integral part of the saddle that attaches it to the long tube, resulting in an extremely rigid connection between the mirrors. The short tube that covers the 4-inch primary does not support the mirror cell but is carried by it.

Two eyepieces, an 18-mm. orthoscopic and a 32-mm. wide-field, combined with a Barlow lens, give a power range from 62 to 330, more than adequate for my locality. These and the finder eyepiece were made from surplus lens sets. The optical elements are mounted in one-piece cells turned from solid Formica and pressed into short lengths of 1½-inch chrome-plated brass tubing. The ends were enameled, labeled with white decals, and finally waxed, for a professional-looking result.

The 2-inch f/7.5 achromatic finder serves as a guide telescope when used with a Barlow lens and short-focus eyepiece. Photographic work awaits completion of a better mounting, but the accompanying



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Tinsley 12-inch does. Its amazing rigidity comes from the positive action clamp mechanism, and its weight. No tremors and blurred images.

(3) The focusing assembly will

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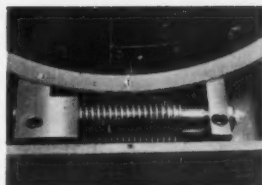
omers — it combines all the best features and engineering principles. For example: rack-and-pinion assembly (superior, by far, to slow-moving spiral assemblies); positive locking clamp for accuracy. The entire assembly can be removed, and replaced with a camera or spectrograph without loss of alignment. The assembly barrel — as you can see — is ruggedly built. Its 3-inch diameter makes it capable of handling larger-than-average eyepieces and accessories.



(4) In the optical system, Tinsley's skill and experience comes into full play. Tinsley has been making professional telescopes for 30 years, and supplies optics for missiles and rockets. The Cassegrain system of the 12-inch has a primary focal length of 48", secondary amplification of 4 and total effective focal length of 192". The telescope is equipped with a finder of 10 power.

(5) In the motor drive and tracking

system there are two Bodine motors in right ascension, one



for a precise sidereal rate; the other for fast drive at 5 times the sidereal rate. Worm gears are precision ground. There is manual declination with anti-backlash drive.

These are only the most outstanding features. As a whole, the Tinsley 12-inch is a remarkable telescope, the ultimate instrument for schools and colleges, universities, astronomy clubs and even individuals. (Yes, some of these fine instruments have been purchased by individual amateur astronomers.)



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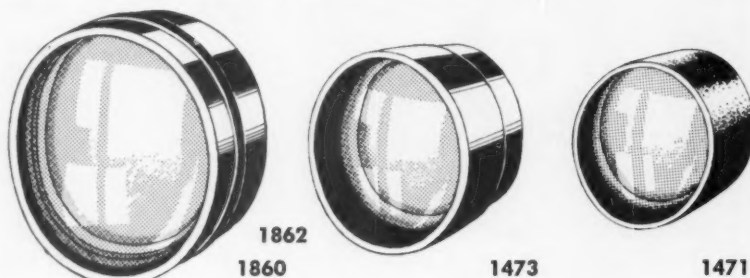
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S-958	2 1/8"	15 1/2"	9.75	S-822	3-3/16"	24 1/2"	22.50	S1159	4 3/8"	42"	60.00
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S-952	2 1/8"	23 1/2"	12.50	S1093	3 1/4"	28"	28.00	S1474	5-1/16"	24 3/4"	75.00
S1431	2 1/8"	30"	12.50	S1139	3 1/4"	30"	28.00	S1475	5-1/16"	24 3/4"	85.00
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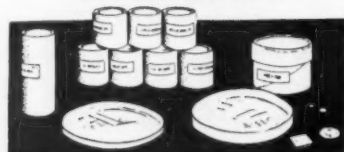
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S2055	8" (flat)	1 3/8"	19.50
S2056	10" (flat)	2 1/8"	30.75*
S2057	12" (flat)	2 1/8"	54.75*

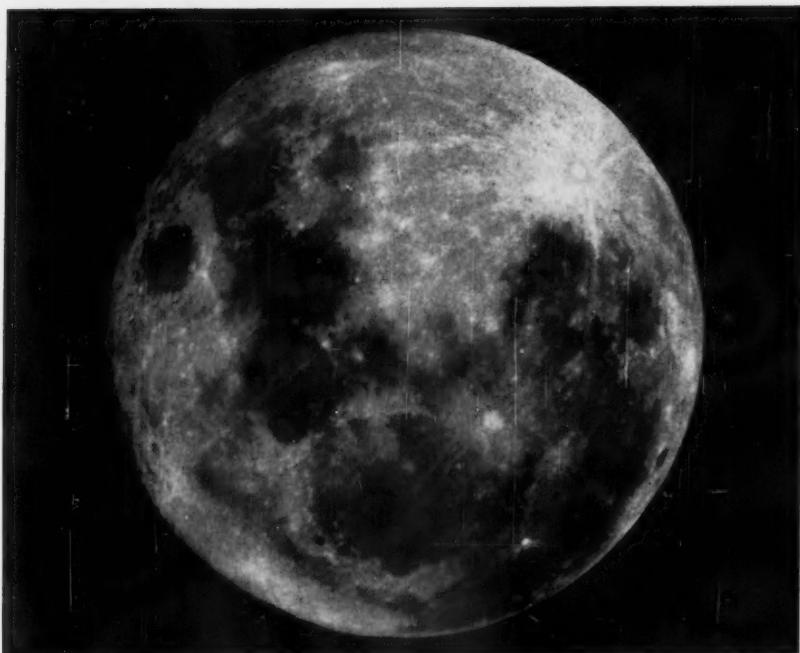
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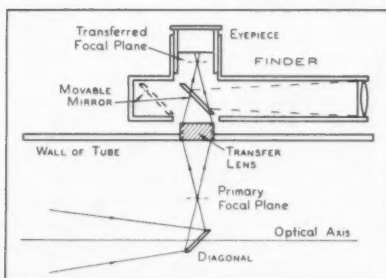


The moon within a day of full phase, photographed by C. B. Avera, Jr., with his homemade 4-inch Schiefspiegler telescope. He used an exposure of 1/250 second at f/19 on Ilford HP3 with normal development in Ilford Microphen, printed on grade 3 paper to bring out weak contrasts.

moon picture shows what can be done with a 35-mm. reflex camera back adapted to the eyepiece drawtube of the 4-inch Schiefspiegler. At f/19, the lunar image is almost $\frac{3}{4}$ inch in diameter and fits easily in a 35-mm. frame. With perfect seeing, the focal ratio should be increased to about 30 or more by means of a Barlow lens or positive eyepiece projection. This would better match the resolving power of the telescope to the resolution of the film, taking the latter to be 60 lines per millimeter.

Although the oblique telescope's image plane is perfectly flat, it is not exactly perpendicular to the secondary's reflected optical axis. The eye compensates for this without difficulty, but in photography the film should be made to lie in that plane by using a tilting camera back.

C. B. AVERA, JR.
4721 Reading Rd.
Cincinnati 37, Ohio



By adding a transfer lens to his main telescope, Dr. W. L. Orr combines its optical system with that of the finder, gaining several advantages.

A NOVEL ARRANGEMENT FOR A FINDER

A TRANSFER LENS can be used to reduce materially the size of the diagonal flat of a Newtonian telescope, as explained in this department for November, 1959, page 53. With such an arrangement, Dr. W. L. Orr, 1952 Fairbanks Ave., Ottawa 2, Ontario, Canada, has mounted his finder so that it shares the same eyepiece as his 8 $\frac{1}{2}$ -inch reflector.

The method is sketched here. Mounted in the wall of the main tube, the transfer lens picks up the reflected focal plane of the primary mirror and forms an image a good distance outside the tube, so far in fact that the finder fits between it and the projected focus. A movable mirror or prism reflects the finder image.

Among the advantages of Dr. Orr's plan are: savings of time, motion, and possible telescope movement when shifting from the finder to the main telescope; no logging of one eyepiece by the observer's breath while he is looking through the other; no special eyepiece needed for the finder and, conversely, as many different powers available for the finder as for the telescope itself. Some amateurs have to take the eyepiece out of the finder when they want a low-power view with the main mirror; that is unnecessary here.

The problem of mounting the finder is simplified, and it is always in as convenient a position as the main eyepiece. A little ingenuity should indicate how to provide for shifting the movable mirror.

R. E. C.

Don't fail to investigate the new 1961 Magnusson telescopes, mountings, and clock drives.

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Made of choice aluminum or brass, machined and polished all over. Hour circles, machine-scribed with hour, half-hour, and five-minute marks.

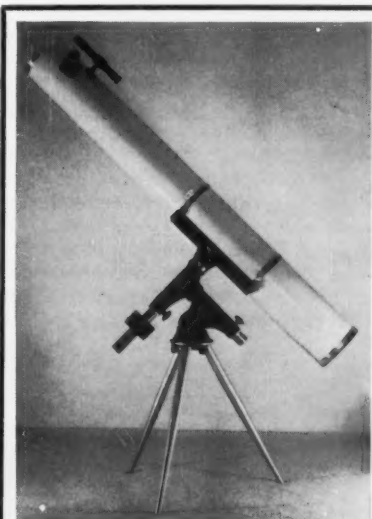


Declination circles scribed in degrees 0-90-0-90. Numbers stamped with $\frac{1}{16}$ " dies. Holes reamed standard sizes. Fastened with setscrews. State hole sizes.

	Aluminum	Brass
5" circles, set of two	\$15.00	\$19.50
6" circles, set of two	\$17.00	\$22.10
8" circles, set of two	\$24.00	\$31.20

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OPTICAL ENGINEERS

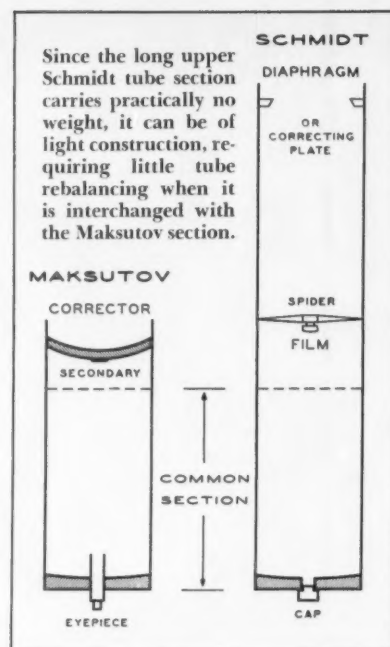
For almost half a century Fairchild Camera and Instrument Corporation has been pioneering and developing airborne photographic systems, instrumentation and equipment, and has become a leading contributor to the nation's airborne intelligence-gathering capabilities.

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A MAKUTOV CONVERTIBLE TO A SCHMIDT CAMERA

TWO telescope systems described in this department in recent years can be combined to give the amateur a novel instrument, usable both as a medium-speed Schmidt camera and a high-power Maksutov visual telescope. This suggestion by Harold M. Hurlburt, P. O. Box 444, Canoga Park, Calif., is based on the Maksutov design of John Gregory (March, 1957, page 236) and the simplified Schmidt camera of L. A. Jones (October, 1959, page 703).

The Gregory-Maksutov has its correcting lens and secondary mirror too close to the main mirror for photography to be done at the prime focus. Yet the spherical primary mirrors of the $f/15$ and $f/23$ instruments have focal ratios of 2.34 and 3.4, respectively, and would be quite suitable for use in Schmidt systems.

Therefore, adopting Mr. Jones's suggestion for a simplified Schmidt, Mr. Hurlburt proposes a diaphragm or opening three-fourths the aperture of the primary mirror. The focal ratio of 2.34 would then become $f/3.1$, and that of 3.4 would be $f/4.5$, quite satisfactory for photography of relatively wide fields. (However, if the primary of an $f/15$ Maksutov has been aspherized to remove residual aberrations, it cannot be converted to a Schmidt.)

If one were making a Maksutov and the main mirror were completed first, it could be used for observing in the simplified Schmidt system while the correcting lens was being fabricated. The completed instrument might be made with interchangeable upper-tube sections, as shown by Mr. Hurlburt's sketch. The Schmidt tube could carry a correcting plate instead of the diaphragm. R. E. C.

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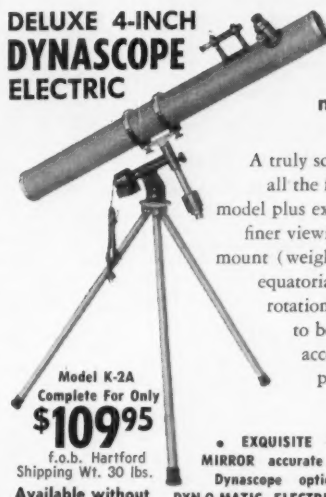


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For those who want the ultimate in an electrically driven 4-inch reflector! This top-performing new DYNASCOPE is actually a 4-inch duplicate of our DeLuxe 6-inch model. You get such truly fine features as a 6 x 30 achromatic finderscope, a fully rotating tube for more comfortable viewing, and a superb optical system that includes five of our finest eyepieces — four achromatic and one orthoscopic. You won't find a finer 4-inch reflector anywhere!

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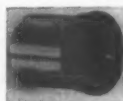
12 different puzzles that will stimulate your ability to think and reason. Here is a fascinating assortment of wood puzzles that will provide hours of pleasure. Twelve different puzzles, animals, and geometric forms to take apart and reassemble; give a chance for all the family, young or old, to test skill, patience, and, best of all, to stimulate ability to think and reason while having lots of fun. Order yours now.

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Wide, flat field — better correction under high magnification — excellent eye relief.

The orthoscopic eyepiece is one of the most important and best corrected eyepieces for astronomical work. These are of a four-element design, with coated lenses, and are standard 1 1/4" outer diameter, precision made of chrome-plated brass and aluminum.



Stock #30,364-Y.....	4 mm.....	\$14.50 ppd.
Stock #30,404-Y.....	6 mm.....	14.50 ppd.
Stock #30,405-Y.....	12.5 mm.....	14.50 ppd.
Stock #30,406-Y.....	18 mm.....	14.50 ppd.
Stock #30,407-Y.....	25 mm.....	14.50 ppd.

Rack-&Pinion Eyepiece Mounts



Real rack-and-pinion focusing with variable tension adjustment; tube accommodates standard 1 1/4" eyepieces and accessory equipment. Lightweight aluminum body casting (not cast iron); focusing tube and rack of chrome-plated brass; body finished in black wrinkle paint. No. 50,077-Y is for reflecting telescopes, has focus travel of over 2", and is made to fit any diameter or type tubing by attaching through small holes in the base. Nos. 50,103-Y and 50,108-Y are for refractors and have focus travel of over 4". Will fit our 2 7/8" I.D. and our 3 7/8" I.D. aluminum tubes, respectively.

For Reflectors

Stock #50,077-Y...(less diagonal holder).....\$8.50 ppd.
Stock #60,049-Y...(diagonal holder only).....1.00 ppd.

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Stock #50,103-Y...(for 2 7/8" I.D. tubing).....\$12.95 ppd.
Stock #50,108-Y...(for 3 7/8" I.D. tubing).....13.95 ppd.

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Ideal for pointing out interesting features on movie and slide projection screens. Excellent lecture tool. For teacher use on maps, etc. Flashlight focuses an arrow where you point it.

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For Exciting Telephoto Shots
Will fit any camera



Camera and binocular attach easily. Use any binocular or monocular — any camera, still or movie. Take color or black-and-white. Attractive gray crinkle and bright chrome finish, 10" long. Full directions for making telephoto pictures included.

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Take Pictures Through Your Telescope with the EDMUND CAMERA HOLDER for TELESCOPES



Bracket attaches permanently to your reflecting or refracting telescope. Removable rod with adjustable bracket holds your camera over scope's eyepiece and you're ready to take exciting pictures of the moon. You can also take terrestrial telephoto shots of distant objects. Opens up new fields of picture taking!



SUN PROJECTION SCREEN INCLUDED

White metal screen is easily attached to holder and placed behind eyepiece. Point scope at sun, move screen to focus... and you can see sunspots!

All for the low, low price of \$9.95

Includes brackets, 28 3/4" rod, projection screen, screws, and directions. Aluminum; brackets black crinkle painted.

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For comfortable viewing of stars that are high in the sky and overhead with reflecting telescopes using standard-size (1 1/4" O.D.) eyepieces, or you can make an adapter for substandard refractors. Contains an excellent high-quality aluminized right-angle prism. The tubes are satin chrome-plated brass. Body is black wrinkle cast aluminum. Optical path length of the system is about 3 1/2".

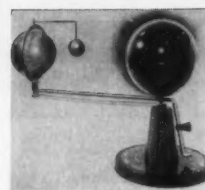
Stock #70,077-Y.....\$12.00 ppd.



AMICI-PRISM STAR DIAGONAL

Same as above except contains Amici roof prism instead of usual right-angle prism. Thus your image is correct as to top-bottom, making it excellent for terrestrial viewing.

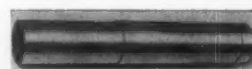
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THE PLANETARIUM PORTRAYS THE FASCINATING STORY OF EARTH IN ACTION

Here is the story of cosmic motions — how the moon revolves around the earth, and the earth around the sun, with our planet rotating simultaneously. With this instrument, the observer sees a three-dimensional moving demonstration of how seasons, day and night, and moon phases occur. This handsome gear-and-chain-driven unit is supported by a smartly finished wood base. The sun is 6" in diameter, and the earth is 4". Planetarium stands 12" high, is 8" wide; arm is 18" long. A completely illustrated, delightfully informative handbook included.

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This Edmund development adds real convenience to viewing objects on the earth. Just put the lens erector in your eyepiece holder, insert eyepiece, and focus normally. You see everything right side up and correct as to left and right. Made of polished chrome-finished brass telescoping tubing that will fit any standard 1 1/4" eyepiece holder. Tubing is 9 1/2" long and slides 3" into eyepiece holder. Erecting system consists of two coated achromats.

Stock #50,276-Y.....\$9.95 ppd.

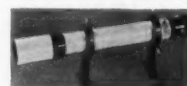
STAR TIME CALCULATOR



This handy slide rule automatically makes the conversion from star or sidereal time to standard time. Saves the amateur astronomer the time and trouble of calculations. Size: 10 1/2" x 3 3/8"; plastic-coated cardboard.

Stock #40,399-Y.....\$1.50 ppd.

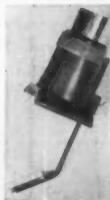
6X FINDER TELESCOPE



Has crosshairs for exact locating. You focus by sliding objective mount in and out. Base fits any diameter tube — an important advantage. Has 2 holders, each with 3 centering screws for aligning with main telescope. 20-mm.-diameter objective. Weighs less than 1/2 pound.

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STANDARD 1 1/4" EYEPIECE HOLDER



Here is an economical plastic slide-focus eyepiece holder for 1 1/4" O.D. eyepieces. Unit includes 3"-long chrome-plated tube into which your eyepiece fits for focusing. Diagonal holder in illustration is extra and is not included.

Stock #60,067-Y.....\$2.50 ppd.

Stock #60,049-Y
Diagonal holder.....\$1.00 ppd.

EDMUND SCIENTIFIC CO.

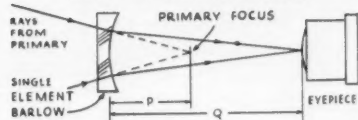
THE ORIGINAL GOODWIN RESOLVING POWER BARLOW



For many years, this achromatic coated Barlow lens has been the pride and joy of serious astronomers. Due to the death of the designer, Mr. Frank Goodwin, it has not been available for the past two years. NOW we can offer these lenses, in exact accordance with the original specifications. Remember, this Barlow is achromatic, coated, mounted in a blackened tube, and as optically perfect as only precision craftsmen can make it. Complete with instructions, in a 4"-long adapter tube for standard 1 1/4" eyepieces.

Stock #60,122-Y.....\$23.50 ppd.

DOUBLE AND TRIPLE YOUR TELESCOPE'S POWER WITH A BARLOW LENS



WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to short focal length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power. The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q.



Beautiful chrome mount. We now have our Barlow lens mounted in chrome-plated brass tubing, with special spacer rings that enable you easily to vary the power by sliding split rings out one end and placing them in other end. Comes to you ready to use. Just slide our mounted lens into your 1 1/4" I.D. tubing, then slide your 1 1/4" O.D. eyepieces into our chrome-plated tubing. Barlow lens is nonachromatic.

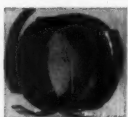
Stock #30,200-Y...Mounted Barlow lens...\$8.00 ppd.

UNMOUNTED 3X BARLOW LENS

These lenses are made for telescopes that have smaller-diameter eyepieces than the standard 1 1/4" size. Mount one between the eyepiece and objective, and triple your power. Instructions included. Single-element lens, focal length — 1-5/16", unmounted.

Stock #30,185-Y....0.932" diam.....\$3.50 ppd.
Stock #30,328-Y....0.912" diam.....\$2.50 ppd.

3X ADJUSTABLE-DIAMETER BARLOW LENS



For telescopes with eyepieces smaller than the standard 1 1/4" outer-diameter size. Prongs on mount can be opened or closed to fit tubes from 13/16" to 1" inner diameter. Directions for using included.

Stock #30,339-Y.....\$5.00 ppd.

MORE POWER FROM YOUR JAPANESE TELESCOPE

Mounted Barlow for Japanese Telescopes

By inserting this single-element lens in the eyepiece end of your Japanese telescope, and putting your regular eyepiece in the end of the Barlow tube, you can increase your telescope's power up to three times. Thus, instead of 60x, you will get 120x or 180x. Barlow is mounted in two pieces of telescoping brass tubing each 4" long, satin chrome plated on the outside. Inner diameter of large tube and outer diameter of small tube are 0.965", the standard size for most Japanese telescopes. Measure yours before ordering. 0.965" is approximately 31/32" or 24.5 mm.

Stock #30,370-Y.....\$4.00 ppd.

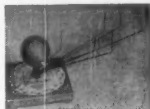
BACKLASH-FREE TUNER GEAR CAN BE USED FOR A MANUAL DRIVE ON SMALL TELESCOPES



Center distance is 0.548", gear diameter 1.687", pinion diameter 0.418".

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ORRERY (Solar System Representation)



Use to show correct positions of planets each month. Sun is represented by 2 1/2" yellow ball, planets by varicolored 3/16" balls. Planets can be rotated freely around Sun. Distance from Sun to Pluto is 16". Base is 6" square. Directions included.

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Demonstrates graphically the incredible distances between planets and the comparative sizes of sun, planets, moons. The sun is represented by an 18" vinyl balloon, earth and planets by metal balls in proportion, 1/8" to 1 1/2" diameters.

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CLOCK-DRIVEN EQUATORIAL MOUNT ON PEDESTAL BASE IDEAL FOR YOUR 6" OR 8" REFLECTOR

Accurate electric clock drive and heavy-duty mounting. Operates on household current. Follows stars smoothly. Pedestal is 24" high. Polar-axis shaft diameter 1". Setting circles included.

Stock #85,111-Y.....\$74.50 f.o.b. Barrington, N. J.

Same mount and clock drive on 32" hardwood tripod.

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Same mount on metal pedestal, no clock drive.

Stock #85,108-Y.....\$45.00 f.o.b. Barrington, N. J.

Same mount on tripod, no clock drive.

Stock #85,023-Y.....\$39.50 f.o.b. Barrington, N. J.



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Here they go — all first-class aerial camera lenses and astronomy sets. Priced to go, along with many other real buys, discounted 25 per cent and now discontinued.

AERIAL CAMERA LENS, f/6, 24" f.l. — was \$39.50.

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ASTRONOMY SET, projects moon travel, eclipses, stellar wonders — was \$5.00.

Stock #70,233-Y.....Now \$3.75 ppd.

DE LUXE ASTRONOMY SET, down from \$10.00.

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GET LISTINGS OF OTHER GREAT SAVINGS IN BARGAIN BULLETIN

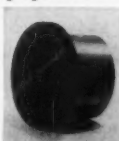
Mounted Ramsden Eyepieces

Standard 1 1/4" Diameter

Our economy model, standard-size (1 1/4" O.D.) eyepiece. We mounted two excellent quality plano-convex lenses in black anodized aluminum barrels instead of chrome-plated brass to save you money. The clear image you get with these will surprise you. Directions for using short focal length eyepieces are included with both the 1/4" and 1/2" models.

Stock #30,204-Y....1/4" focal length.....\$4.75 ppd.

Stock #30,203-Y....1/2" focal length.....\$4.50 ppd.



SETTING CIRCLES TO FIT YOUR EDMUND TELESCOPE OR TELESCOPES WITH SIMILAR-SIZED MOUNTS



A — Heavy-Duty



B — Light-Duty

(A) FOR HEAVY-DUTY MOUNT (fits Edmund 6" reflector, 4" refractor). Black plastic. Hour circle has two scales, bottom 0 to 24 hrs., top 0-6, 6-0, etc. Declination circle has numbers every 10°, lines each degree. All filled white. Hole is 1.9"; 3" outer diameter. Two pointers with 2 1/4" holes.

Stock #60,188-Y.....\$3.00 ppd.

(B) FOR LIGHT-DUTY MOUNT (fits Edmund 4 1/4" reflector, 3" refractor). Black plastic, scales same as above. 1"-diameter hole; 3" outer diameter. Two pointers with 1 1/4"-diameter holes.

Stock #60,187-Y.....\$3.00 ppd.

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MOLECULE AND CRYSTAL MODELS KIT — Rods and balls to make atomic models, plus directions.

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GIANT ERFLE EYEPIECE 1 1/2" F.L.

War-Surplus Bargain — Gov't. Cost Approx. \$100

Large telescopes should have one of these for low-power viewing. Apparent field of view 65°. Also use with our 24"-focal-length Aerial Camera lens to make a 16-power wide-field telescope or a 27-power scope with one of our 40"-focal-length Aerial Camera lenses. Low-reflection-coated, 5-element lens system. Field lens of Eastman Kodak's rare-earth glass for better aberration correction. Has diopter scale. Smooth focusing, 3/8" movement. Outside diameter of attaching threads, 3" — 32 threads per inch. Clear aperture of eye lens 2", field lens 1-25/32". Weight 3 1/2 lbs.

Stock #50,091-Y.....\$9.95 ppd.



ADAPT GIANT ERFLE TO STANDARD TELESCOPE EYEPIECE SIZE

This adapter lets you use our Giant Erfle with any telescope having a standard 1 1/4"-diam. eyepiece holder.

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CELESTIAL CALENDAR

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DELTA LIBRAE

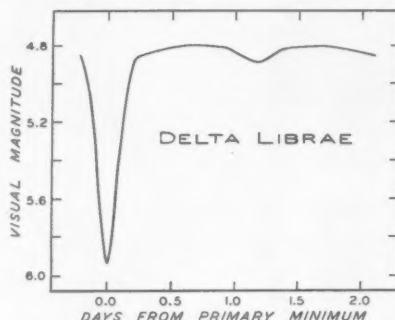
ON May evenings, an otherwise rather blank expanse in the southeastern sky is marked by the stars Alpha and Beta Librae, harbingers of the brilliant summer constellations Scorpius and Sagittarius. Four degrees west of Beta is the eclipsing variable star Delta Librae, an attractive object for observers using binoculars.

Delta Librae is very similar to Algol in period length, magnitude range, and form of light curve; it could be described as Beta Persei made three magnitudes fainter and transferred to the opposite part of the sky.

Normally Delta is magnitude 4.8, but at intervals of 2.327 days it fades to 5.9. Each of these eclipses is 13 hours long, but, as the accompanying light curve shows, most of the change occurs during the three hours preceding and the three following minimum light.

The variability of Delta was first recognized in April, 1859, by J. F. J. Schmidt at Athens. At that time only three other Algol-type variables were known, Beta Persei, S Cancri, and Lambda Tauri. He thought the period was seven days, and only several years later was it ascertained that this was three times the true cycle. Despite a century of observation, Delta Librae remains one of the few well-studied eclipsing variables for which period changes have never been reliably established.

The following predictions for mid-points of primary minima are expressed in Universal time, to the nearest 0.1 hour: May 2, 2^h 2; 4, 10.0; 6, 17.9; 9, 1.7; 11,



This photoelectric light curve was observed by Joel Stebbins in 1920-24. Note the shallow secondary minimum, only 0.06 magnitude deep, that occurs about 1.2 days after primary eclipse, as the cooler star of this binary passes behind the hotter one. Adapted from "Publications," Washburn Observatory.

9.6; 13, 17.4; 16, 1.3; 18, 9.2; 20, 17.0; 23, 0.9; 25, 8.7; 27, 16.6; 30, 0.5.

June 1, 8.3; 3, 16.2; 6, 0.0; 8, 7.9; 10, 15.7; 12, 23.6; 15, 7.4; 17, 15.3; 19, 23.2; 22, 7.0; 24, 14.9; 26, 22.7; 29, 6.6.

Any star atlas will serve for the identification of Delta Librae, whose 1950 coordinates are 14^h 58^m.3, -8° 19'. The following stars are suitable as comparison objects, and are all similar in color to the variable. Their magnitudes are Harvard visual values.

Star	R. A.	Dec.	Mag.
16 Librae	14 ^h 54 ^m .6	- 4° 09'	4.6
ε Librae	15 21.5	-10 09	5.1
μ Librae	14 46.6	-13 57	5.4
GC 20158	14 56.3	- 4 47	6.0
GC 19695	14 34.3	-12 06	6.2

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MAY METEORS

Observations of the Eta Aquarid meteors this year will be hampered by the moon, which reaches last quarter on May 7th. Shower maximum occurs on the night of May 4-5, with the radiant at right ascension 22^h 24^m, declination 0°.

MINOR PLANET PREDICTIONS

Phocaea, 25, 9.9. May 11, 17:00.3 -2.42; 21, 16:54.4 +0.45; 31, 16:46.5 +3.56. June 10, 16:37.8 +6.37; 20, 16:30.0 +8.32; 30, 16:42.2 +9.39. Opposition on June 3rd.

Niobe, 71, 10.7. May 21, 18:14.9 -55.37; 31, 18:04.4 -55.42. June 10, 17:50.7 -55.12; 20, 17:36.1 -54.03; 30, 17:23.1 -52.18. July 10, 17:13.5 -50.05. Opposition on June 17th.

After the asteroid's name are its number and the approximate visual magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0^h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

VARIABLE STAR MAXIMA

May 7, V Cassiopeiae, 230759, 7.9; 9, T Columbae, 051533, 7.5; 17, R Sagittarii, 191019, 7.3; 23, T Cassiopeiae, 001755, 7.8; 23, U Ceti, 022813, 7.5; 25, RR Sagittarii, 194629, 6.8; 28, U Orionis, 054920a, 6.3.

June 2, T Ursae Majoris, 123160, 7.7; 7, T Centauri, 133633, 5.5.

These predictions of variable star maxima are by the AAVSO. Stars are listed only if brighter than magnitude 8.0 at an average maximum. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for their maxima. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted visual magnitude.

MOON PHASES AND DISTANCES

Last quarter May 7, 15:58
New moon May 14, 16:55
First quarter May 22, 16:19
Full moon May 30, 4:38
Last quarter June 5, 21:19

May	Distance	Diameter
Perigee 6, 12 ^h	229,600 mi.	32' 20"
Apogee 21, 5 ^h	251,300 mi.	29' 33"
June		
Perigee 2, 3 ^h	227,000 mi.	32' 43"

MINIMA OF ALGOL

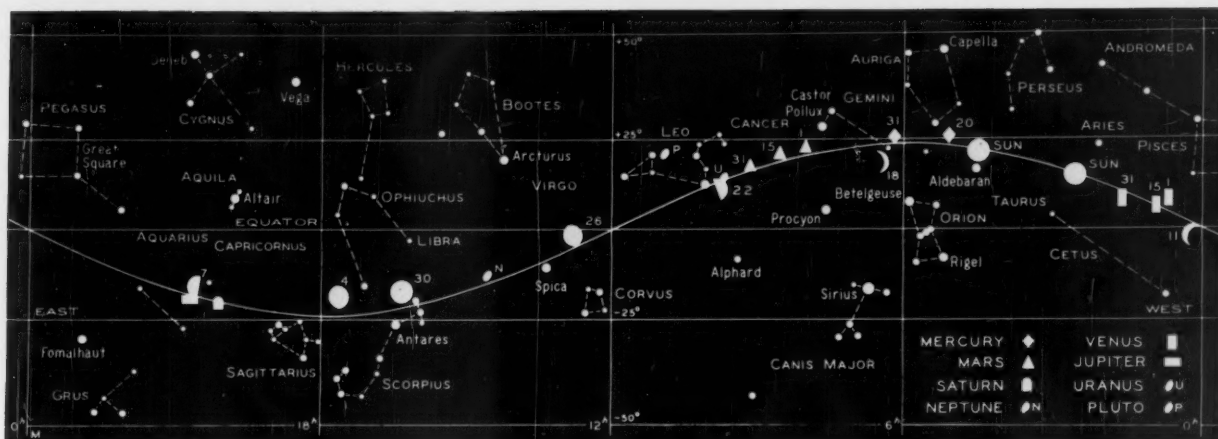
May 1, 9:58; 4, 6:47; 7, 3:36; 10, 0:25; 12, 21:14; 15, 18:03; 18, 14:52; 21, 11:41; 24, 8:30; 27, 5:19; 30, 2:08.

June 1, 22:57; 4, 19:46; 7, 16:35.

These minima predictions for Algol are based on a recent timing by D. Engelke, and an assumed period of 2.8674 days. The times given are geocentric; they can be compared directly with observed times of least brightness.

UNIVERSAL TIME (UT)

TIMES given in Celestial Calendar are Universal time (Greenwich civil time) unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. To obtain daylight saving time subtract 4, 5, 6, or 7 hours, respectively. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown. For example, 6:15 UT on the 15th of the month corresponds to 1:15 a.m. EST on the 15th, and to 10:15 p.m. PST on the 14th.



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other dates shown.

All positions are for 0^h Universal time on the respective dates.

Mercury is at superior conjunction on May 1st, and is thus too close to the sun to be seen during the early part of this month. By the 15th, however, it will be well placed in the western evening sky, setting about 1½ hours after the sun. On that date a telescope will show Mercury as a gibbous disk, 80-per-cent illuminated and 5".7 in diameter. Greatest eastern elongation will be reached on June 1st, when the planet will be an 8" crescent.

Venus, rising about 1½ hours before the sun, is readily found low in the eastern sky during morning twilight. Greatest brilliancy occurs on May 16th, with the planet at magnitude -4.2. With telescopic aid it can be seen on that date as a crescent, 39" in diameter and 10" broad.

Mars, which reaches aphelion on May 5th, 155,000,000 miles from the sun, is seen easily in Cancer in the western sky after sunset. No longer prominent, the planet is of magnitude +1.5, its small red disk appearing only 5½" in diameter. Mars will pass in front of the Beehive cluster on the night of May 17-18, and observers with binoculars will find it interesting to follow the planet beginning a day or so before this event.

Jupiter rises about midnight on May 15th and is visible in Capricornus in the southeast, as a bright yellow object of magnitude -2.0. Its disk appears slightly flattened, 38".7 in polar diameter and 41".5 in equatorial. Stationary in right ascension on the 26th, Jupiter then begins retrograde (westward) motion among the stars. The moon passes 3° north of the planet on the evening of May 6th.

Saturn, three months after its conjunction with Jupiter, is in Capricornus about 7° west of that planet. Its magnitude is +0.7. On the 9th Saturn becomes stationary in right ascension, before beginning retrograde motion. The moon passes 3° north of Saturn during the daytime on May 6th.

Uranus on the 15th is a 6th-magnitude

object in Leo at right ascension 9^h 36^m.9, declination +15° 00' (1950 co-ordinates); it crosses the meridian about an hour before sunset.

Neptune is observable with small telescopes low in the southeast at sunset, its tiny greenish disk being 2".5 in diameter. On the 15th of the month, the 1950 co-ordinates of this 8th-magnitude planet are 14^h 30^m.4, -12° 54'.

WILLIAM H. GLENN

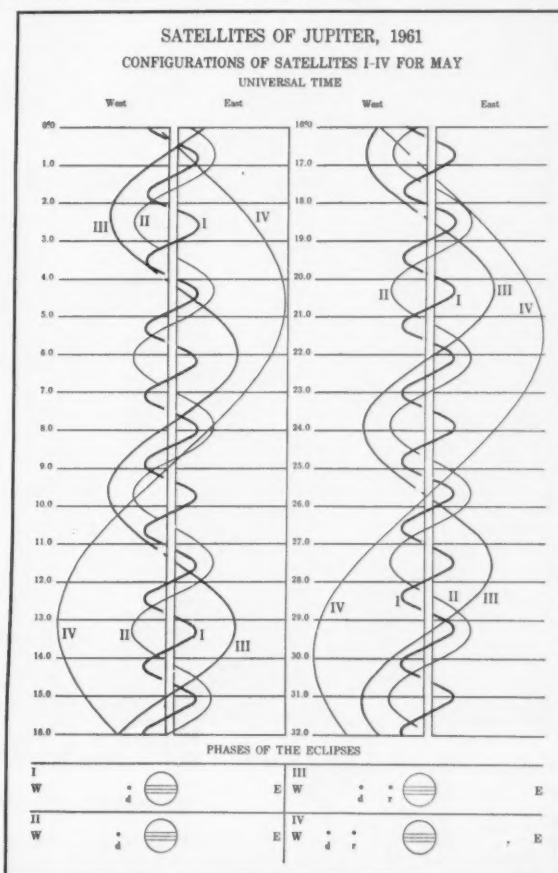
JUPITER'S SATELLITES

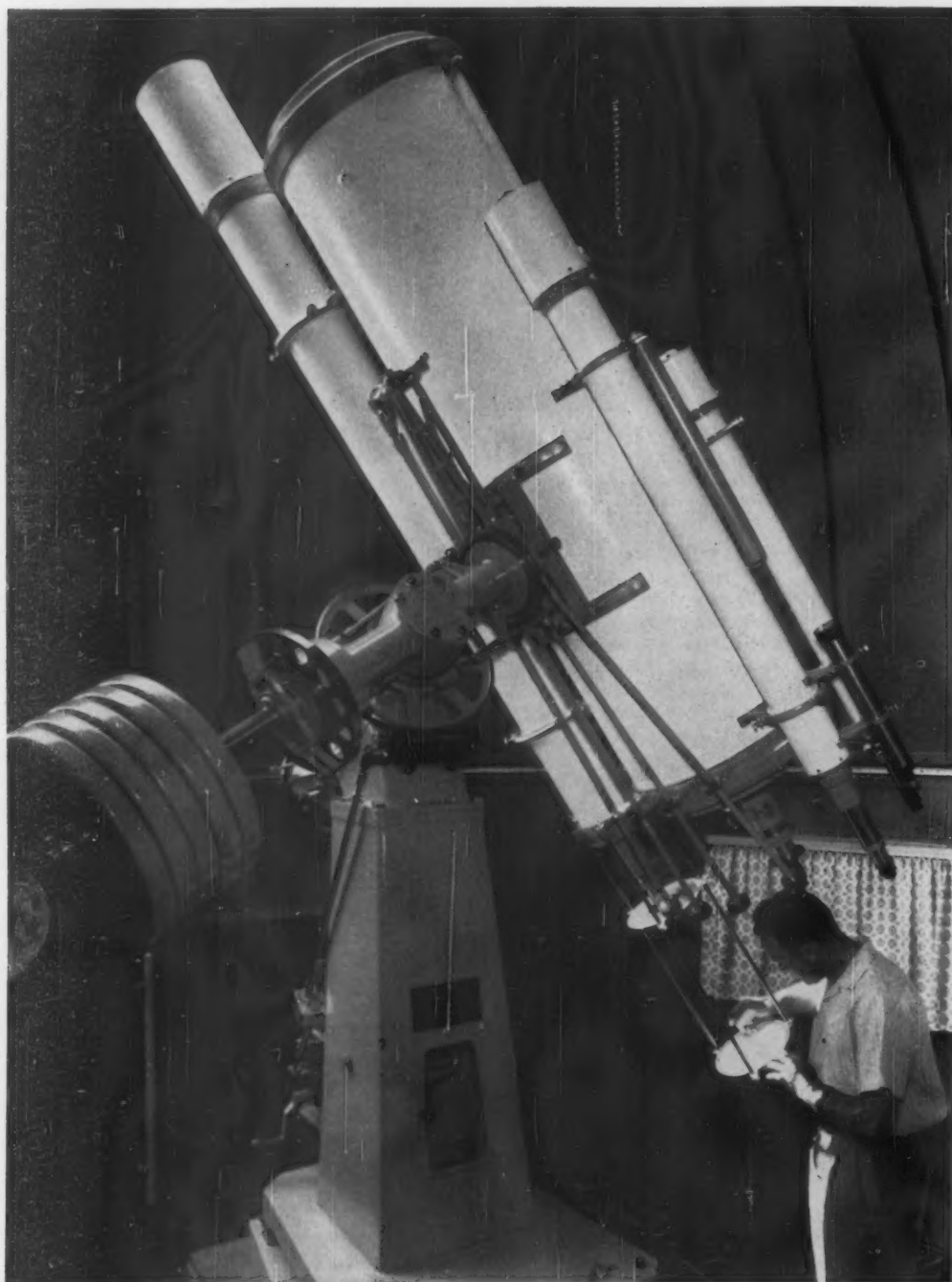
The four curving lines represent Jupiter's four bright (Galilean) satellites: I, Io; II, Europa; III, Ganymede; IV, Callisto. The location of the planet's disk is indicated by the pairs of vertical lines. When a satellite transits in front of Jupiter, its curve crosses the lines. If a moon is invisible because it is occulted by Jupiter or is in its shadow, the curve is broken.

For successive dates, the horizontal lines mark 0^h Universal time, or 7 p.m. Eastern standard time (4 p.m. Pacific standard time) on the preceding day. Along the vertical scale, 1/16 inch is about seven hours. In this chart, west is to the left, as in an inverting telescope for a Northern Hemisphere observer. At the bottom, "d" is the point of disappearance of a satellite in Jupiter's shadow; "r" is the point of re-appearance. From the "American Ephemeris and Nautical Almanac."

ALDEBARAN OCCULTATION

On the 15th of May, the bright star Alpha Tauri will pass behind the day-old moon, at about 22^h Universal time. Since this event occurs during daylight over North America, with the sun only about 15 degrees of arc away from the moon, its observation will be exceedingly difficult. The slightest haze will make the background sky too bright for the star to be seen with even a large telescope. Predicted times for the phenomenon throughout the United States and Canada can be obtained from the Occultation Supplement of the December, 1960, SKY AND TELESCOPE, page 349.





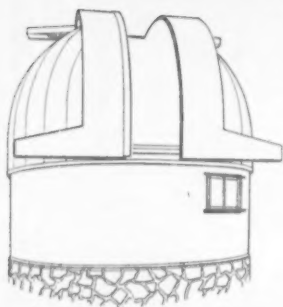
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STARS FOR MAY

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of May, respec-

tively. For other dates, add or subtract ½ hour per week.

About five degrees of arc separate the pointer stars in the Big Dipper, which is on the meridian at chart time. This con-

venient measure aids in finding other celestial objects; for example, the planet Uranus, magnitude 5.8, is located this month about 7½° northwest of 1st-magnitude Regulus in Leo.

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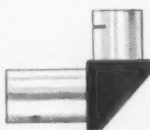


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30	61	2.7	7
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60	32	1.3	1

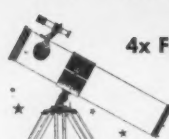
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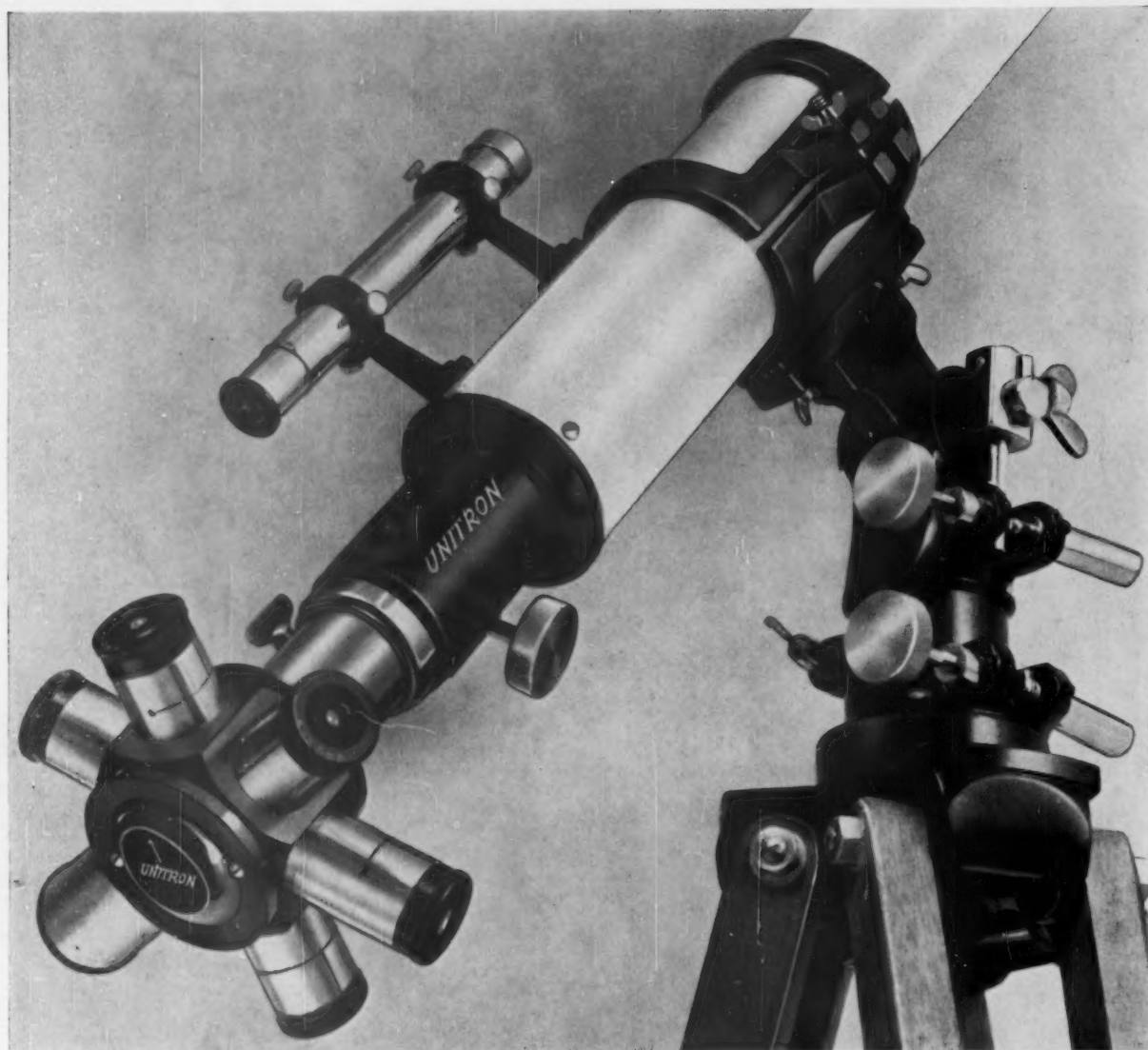
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